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CAST IRON HOWITZER.

WE illustrate below a 12 in. cast iron built-up howitzer, designed by Lieut.-Colonel S. Ordonez, of the Spanish artillery, which, according to *Engineering*, has recently been tested at the butt proof of the Artilleria Fabrica de Trubia, Detall, Spain, and at the port of Gijon, giving satisfactory results. The engraving, Fig. 1, shows the general construction of the gun, and the gearing for training and elevating it. As is shown by Fig. 3, the breech of the gun is built up of steel rings shrunk on over the cast iron A tube, while the breech mechanism is on the interrupted screw principle. Fig. 4 shows the mechanism and Fig. 5 the rifling. We tabulate the principal dimensions of the gun:

30·5 *cm.* (12·01 *in.*) *Cast Iron Built-up Howitzer.*

Caliber	305 mm.	12·01 in.
Weight of the howitzer	14,500 kg.	14·27 tons.
Length of the bore	12·5 cal.	12·5 cal.
Preponderance with breech screw	63 kg.	132·3 lb.
Weight of the charge	35 kg.	77·16 lb.
Density " "	0·70	0·70
Volume of the chamber	50 dm.³	3,051 cub. in.
Weight of the projectile	275 kg.	606·3 lb.
Initial velocity	344 m.	1,129 ft.
" energy	1,660 m. tons.	5,360 foot tons.
Normal pressure	1,700 kgcm.²	10·79 tons per sq. in.
Range for 45 deg.	9,800 m.	10,717 yards.
Number of grooves	48	48

Equation of the rectified parabola, which commences with one turn in 50 calibers and ends with one turn in 25,

$$y = 0{\cdot}0000\ 10097\ x^2 + 0{\cdot}06283\ x.$$

Elastic tangential resistance of the howitzer	1,700 kgcm.²	10·7 tons per sq. in.

This howitzer was tested at Gijon, where thirty-five rounds were fired. Different powders were employed, but that adopted for the howitzer was the German powder E. S. T., and the weight of the charge 35 kilogrammes (77·161 lb.) With this charge the pressure in the bore was 1,700 kilogrammes for cm.² (10·79 tons per square inch), the initial velocity 370 meters (1,350 ft.), and the range with this velocity and 45 deg. was 9,914 meters, 10,840 yards. The time of flight was 47 seconds. The carriage is so constructed as to admit of the howitzer being fired at an angle of 60 deg., but the trials in this last condition have not yet been made. The accuracy of the fire was remarkably good.

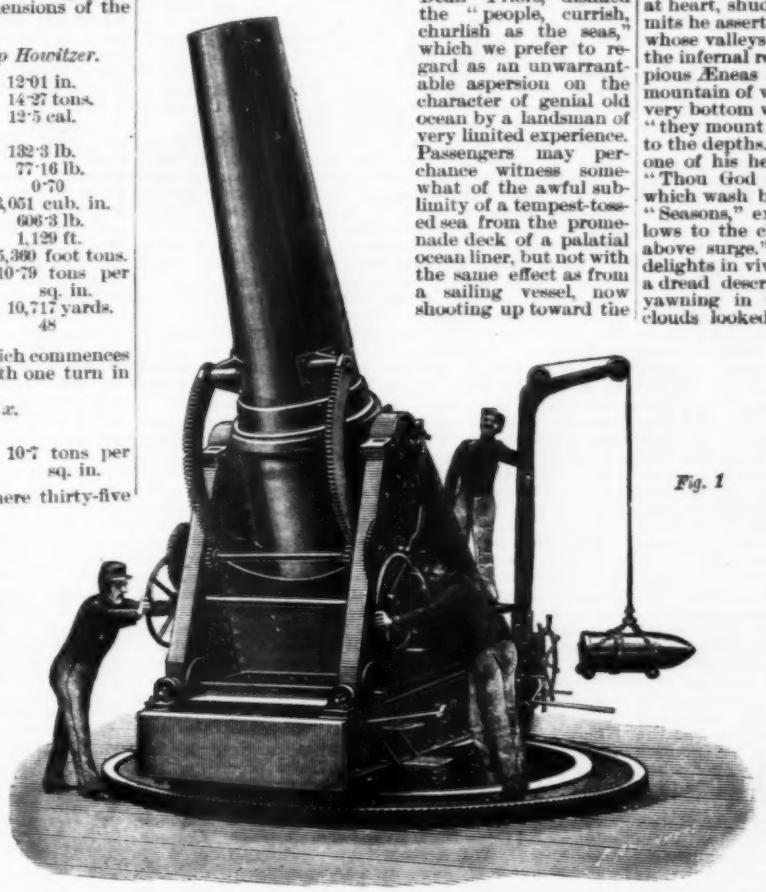


Fig. 1

CAST IRON HOWITZER

OCEAN WAVES.

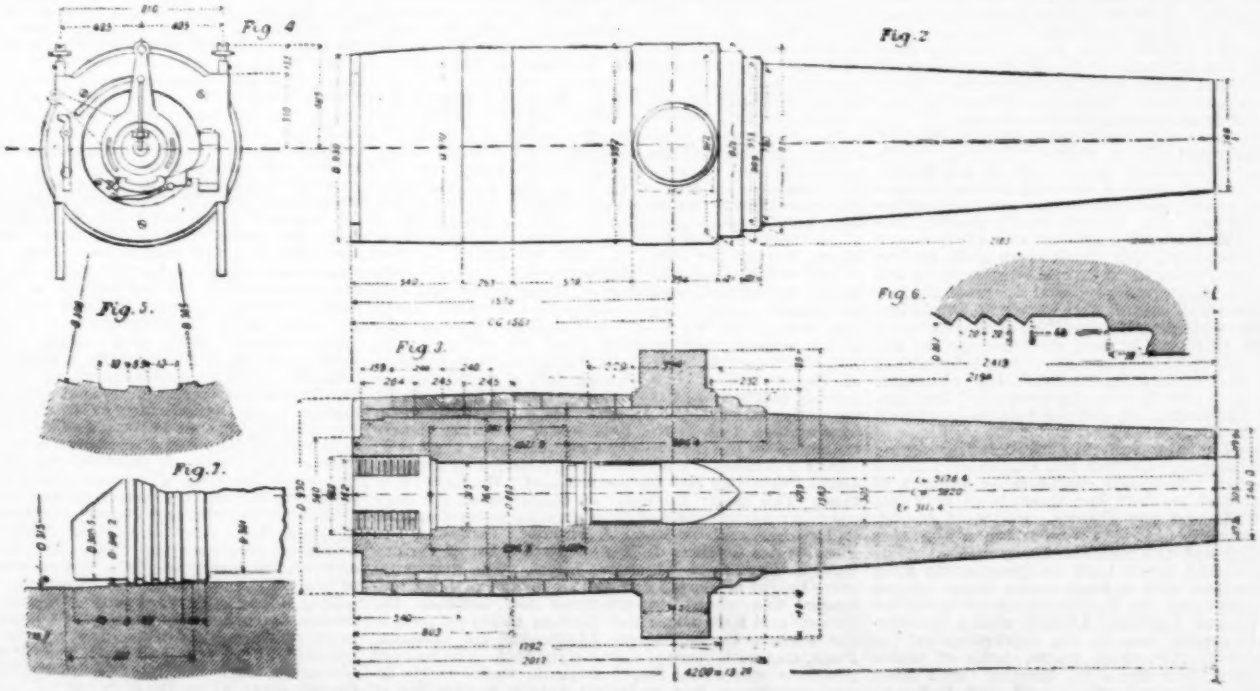
By WILLIAM ALLINGHAM.

A SEA without motion would be not only monotonous but mischievous. Wild waves deal death to human beings, yet undoubtedly subserve a most useful purpose. A stagnant waste of waters, slimy and corrupt, would in time become a fertile source of pestilence and famine. Fearful following seas viewed from the deck of a well found sailing ship running before a gale of wind afford food for reflection; and the illustrious Darwin has felicitously expressed this opinion in his classic "Voyage Round the World," where he says, "It is well once to behold a squall, with its rising arch and coming fury, or the heavy gale of wind and mountainous waves." Nevertheless, there is another side to the picture, for Herrick, living in his Devonshire vicarage of Dean Priors, disliked the "people, currish, churlish as the seas," which we prefer to regard as an unwarrantable aspersion on the character of genial old ocean by a landsman of very limited experience. Passengers may perchance witness somewhat of the awful sublimity of a tempest-tossed sea from the promenade deck of a palatial ocean liner, but not with the same effect as from a sailing vessel, now shooting up toward the heavens as though impelled by a gigantic catapult, and again lost to view in the dark gulfs between the towering crests. Securely sails the triumph of man's power over nature, "while around the lashed ocean, like mountains in motion," as Shelley sang, develops its fury. Poets and novelists have delineated the features of the waste of waters in sunshine and in storm. Ulysses must surely have been under the influence of a cyclone, if we are to believe good old Homer's statement:

"Down rushed the night; east, west, together roar,
And south, and north, roll mountains to the shore."

Ovid, bound to a land of exile, seasick and sorrowful at heart, shuddered at the wanton waves whose summits he asserted seemed about to touch the stars and whose valleys appeared within measurable distance of the infernal regions. Virgil describes the tiny craft of pious Æneas seeking a new home as borne aloft on a mountain of water, or sinking into an abyss where the very bottom was laid bare. The Psalmist tells us that "they mount up to the heavens, they go down again to the depths." Shakespeare puts into the mouth of one of his heroes, in unconscious imitation of Ovid, "Thou God of the great vast, rebuke those surges which wash both heaven and hell." Thomson, in the "Seasons," exclaims: "Meantime the mountain billows to the clouds, in dreadful tumult swelled surge above surge." Ouida, a well known authoress, who delights in vivid imagery, however exaggerated, gives a dread description of "a night with the black seas yawning in fathomless graves," when "the dense clouds looked to stoop and touch the waves where they rose—a mighty wall of water, mountains high." We have here, in sober prose, all the attributes of poetic license; and it is well to remember with Wordsworth that "all things are less dreadful than they seem," especially with shorefolk treating on nautical matters. Charles Reade, in a most interesting yarn of a ship's experience, says that "the overwhelming sea ran in dark watery mountains, crested with devilish fire," and that "the mighty mass struck her stern frame, with the weight of a hundred thousand tons of water." This is rather a tall order, as our American kinsmen would say; and it was reserved for this celebrated novelist to picture a burning mountain—a volcano—under way in midocean.

Enough has been written to show that if, as Horace says, the greedy sea is a destruction for sailors, it is also a source of terror to those who agree with George Herbert that it is well to speak of the sea, but better to stay on land. After all, in our opinion, the best description of the sea in a warring mood has been penned by a seaman—the lamented Maury—whose sympathy with "those who go down to the sea in ships" was deep and widespread. Speaking of 46° south latitude as the favorite parallel for running the easting down by ships bound to the anti-



30·5 CENTIMETER (12·01 INCH) CAST IRON HOWITZER.

podes, he mentions that all the characteristics of the roaring forties are exhibited there, and the billows lift themselves up in long ridges with deep hollows between them. They ran high and fast, tossing their white caps aloft in the air, looking like the green hills of a rolling prairie capped with snow, and chasing each other in sport. Still their march is stately and their roll majestic. Poor Tom Hood gave a very good word picture of a sea in one of his mirth-provoking poems:

"Ah, me! it was a dreary mount! Its base as black as night,
Its top of pale and livid green, its crest of awful white."

Byron has somewhere said that truth is stranger than fiction, and even if one tithe be true of the nautical yarns relating to seas actually met with, then the poet's contention is borne out to the last letter. The bark Hesper, bound from San Francisco to Yokohama last October, narrowly escaped destruction when about seventy-five miles from the nearest point of Japan. A rumbling noise was heard, and almost immediately she was thrown on to her beam ends and overwhelmed on all sides by waves of enormous height. Her crew had to take to the rigging for five hours, owing to the fact that the water was almost boiling hot, and melted the pitch of her deck seams. They were nearly suffocated by sulphurous fumes, and the Hesper rolled so heavily that her masts were expected to go by the board every instant. At the end of eight hours the normal terrestrial condition of things reasserted itself, and she was eventually brought into port. We have failed to find any confirmation of the newspapers reports, neither have we seen any contradiction thereof. Then, again, the recent loss of the steamship Prince Soltykoff is another case in point. Mr. J. G. Haggard, British Consul at Brest, reported that this ill-fated steamship was found by her master to be in danger of drifting on to Ushant in awful weather and high sea. His only chance of escape from the reefs at the northwest end of that cape was to take the inner passage, of which he was ignorant; and, while debating, his ship was suddenly overwhelmed in a most remarkable manner. In an instant she shipped huge waves from every direction, and either sank bodily under this extra weight of water or was sucked down in a miniature maelstrom. The sequel was no less marvelous. The sea became smooth almost by magic, leaving two boats floating peacefully with three survivors in them. All her crew, except those drowned in the engine room, were on her bridge; but, although the night was clear, not one other than these three could be seen in the water. An officer, Mr. Kelk, was the sole survivor, after thirty-two hours' exposure in an open boat, which drifted ashore among the Porsal Rocks. Something similar happened to the Austrian Lloyds steamer Stamboul in April, 1847. She was bound for Constantinople, and, when about one hour from Sinope, the sea opened under her, assuming the form of a huge tunnel. The waves in closing covered her entirely fore-and-aft, so that her escape from foundering is little short of miraculous, if the tale be true, and it certainly seems well authenticated. Not the slightest earthquake symptom was felt along the neighboring coast. We have seen it stated that Captain Parsell, of the White Star steamships, once had a curious proof of what a sea can do when put to it. Chief officer of a 900 ton ship, outward bound from London, he went aloft to catch a fleeting glimpse of the Eddystone; and, when some 60 ft. from the deck, heard a shout, looked down, saw a mass of water strike his ship amidships, which reached his elevated position and deposited him, safe but shaken, in the maintop. His ship suffered; but a brig to leeward had masts and spars taken out in the twinkling of an eye, and the whole watch on deck went with them. It is a common experience of seafarers that even in bad weather, when the seas are exceptionally high, one sea higher than all its fellows will suddenly appear and fill the decks of a vessel hitherto comparatively dry and comfortable. Such a wave is sometimes erroneously referred to in newspaper reports as a tidal wave. Missing ships may in some instances be caused to founder in this way without leaving a trace. A terrible mountain of water swept over the Italian bark Rosina while all hands were shortening sail, and not a man was left, except a poor fellow who happened to be sick in his bunk below. She was bound from Catania to New York in October, 1888; and the solitary survivor remained monarch of all he surveyed for eight days, when a passing ship took him off the doomed bark. While wearing off the Cape of Good Hope, the fine four-master Loch Torridon took a wave over the stern, which swept her master and nearly all one watch into eternity.

About eight years ago a savage sea was shipped by the once celebrated China clipper Undine, which washed away the second mate and all his watch. Captain Bristow lay crushed beneath a spar till daylight, when his body was discovered. Another famous clipper of her day, the United States packet ship Dreadnought, was much mauled by one of those exceptionally heavy seas. All hands were aloft reefing topsails in a hard gale, when her master noticed the approach of the giant, and prepared to resist the unavoidable impact. Tons of water washed him to leeward and rendered himself insensible. Upon regaining consciousness, he found himself stretched across the lee rail, and only held from a watery death by a loose spar which had luckily jammed his leg, although, unfortunately, at the expense of a compound fracture. Her rudder was broken off, and she had to be steered by the sails for the nearest land under the guidance of her undaunted master suffering excruciating agony from his unset limb. In 1887 the Cunarder Umbria shipped one sea which did considerable damage to deck fittings, and reached her mast head fifty feet high. Last August the Etruria, westward bound, shipped a sea while nine men were setting a jib. One man was killed and the others seriously injured. The Germanic once had to put back to Queenstown after trying conclusions with a huge ocean wave. A sea which broke on board the Vancouver swept away her genial commander Captain Lindall and a quartermaster. Her master was in the chart room and the quartermaster in the wheel house, both of which structures went over the side, carrying with them their occupants. Several officers and men had very narrow escapes at the same time. In November, 1890, a mountain sea stove a hole in the bow of the steamship Venetian, and broke four angle irons inside the plates. Two boats were damaged, one demolished, and six ventilators washed away. Last February it was reported that an "enormous tidal wave" swept over the steamer Elvaston in 42° N., 51° W., which killed one man, smashed a boat, and did other damage on deck. In 1888 the bark Lutterworth, running down her easting in 44° S., 30° E., was making very good weather, when a wave was seen rapidly bearing down upon her of an immense height. It broke on board, filling her decks fore and aft. Maury has left on record that a single sea swept one hundred and seventy-nine soldiers and officers from off the deck of a new steamship, which eventually foundered, the San Francisco, bound from New York to California, in December, 1853, while crossing the Gulf Stream. Masters cannot be too often reminded of the power possessed by oil in smoothing an angry sea. The North Atlantic Pilot Chart, published by the United States Hydrographer every month, not infrequently furnishes instances of the success attending the use of oil for this purpose. Ships of the olden time, when passages were not reckoned to the nearest fraction of a minute, and competition among owners was less reckless, often used sea anchors to prevent them from wallowing in the trough. North Sea fishermen were wont to use a drogue, and Franklin improved upon their crude idea. With short ships of small tonnage a drogue may work very well, but it is open to doubt whether this system would be a success if applied to a steamship five hundred feet long. During the American War of Independence, the President fell into the hands of the British, and two days later was dismasted and in danger of foundering. An umbrella anchor was veered out which saved the ship and all on board. Years ago H.M.S. Cleopatra, when dismasted, rode easily for three days to seventy fathoms of cable payed out of her hawser holes. Theory and practice do not always square on such occasions, and the highest authorities agree to differ on this point.

The highest waves, as might fairly be expected, are met with in the lone Southern Ocean, along the 40th parallel of south latitude, where they have a good feteh and but little land in the way. Scoresby, more used to narrower northern waters, marveled at the high waves he saw, while a passenger on board the Royal Charter, between the Cape and Australia. The height of waves is said to vary in the several oceans, and exact measurements tend to prove that exaggeration is not wanting in popular descriptions, whether poetry or prose. An encyclopedia of repute gives twenty feet as the maximum altitude of ocean wave summits, whereas Dumont d'Urville asserted that he had met with one which was one hundred feet in height from trough to crest! In January, 1875, Captain Kiddle, of the steamship Celtic, when in 48° N., 40° W., found from reliable observations of several waves that their mean height was no less than seventy feet, with a velocity of twenty-five knots an hour. The late Admiral Fitzroy, of "Weather Book" fame, had previously measured waves of this stupendous height; and quite recently the Hon. Ralph Abercromby, a very careful observer, used to sea work, has measured waves nearly fifty feet high. It would appear that from thirty to forty feet is about the average height of ocean waves in a storm; but, as we have pointed out, exceptional waves certainly do occur, and these may be quite seventy feet high, as recorded by such eminent authorities as Kiddle and Fitzroy. Seamen are well aware that running in a heavy gale under a reefed foresail is a dangerous maneuver. This low sail becomes becalmed when the ship is in a wave hollow—she loses way, and runs an imminent risk of being pooped. Admiral Fitzroy has related, in seamanlike diction, that H. M. S. Thetis had her two trysails thus becalmed; for, when upright in the trough of the sea, the crests of the preceding and following waves were on a level with the center of the warship's main yard, which was sixty feet from the water line. A United States monitor, the Monadnock, went round Cape Horn some years since, and Commodore Rogers, U.S.N., officially reported that while watching the behavior of the monitor in a gale off Point Concepcion, from her consort the Vanderbilt, he observed two successive waves, interposed between his eye (twenty-five feet above the sea surface) and the mast head of the Monadnock, which was seventy-five feet in height. When our discovery ships Erebus and Terror were in the vicinity of the Antarctic land it was noticed that one ship was on top of a wave, while the other was similarly situated on the next to leeward, and the yawning chasm between them was filled with heavy masses of ice. When the good ships were sailing in alternate hollows, then the main topsail yard of each could be just made out from the other on a level with the crest of the intervening wave, which shut out all below that height from view. It has been asserted that a vessel on the top of a huge wave crest has a virtual weight twenty per cent. less than her actual weight, owing to the decreased effect of the earth's attraction, while down in the hollow about twenty per cent. is similarly added to her actual weight, but this statement bearing indirectly on the rolling and capsizing of ships under sail has not passed unchallenged. Discussion of ocean waves has been attended with some curious results. In 1874 a scientific paper noted that the taffrail of an Atlantic liner frequently falls through a vertical space of thirty feet in one second, but a contemporary quickly pointed out that a body falling freely under the action of gravity only manages to clear a fraction over sixteen feet in the first second, a result clearly indicated by the elementary formula, space $= gt^2 \div 2$; where g denotes the acceleration produced by gravity, about thirty-two feet per second, and t the interval of time. The *Revue Maritime et Coloniale* of last January, in a continuation of its interesting series of articles on Oceangraphy by Mons. J. Thoulet, Professor à la Faculté des Sciences de Nancy, gives a list of various wave heights, from which we quote. The maximum wave height measured during the voyage of the Challenger was about twenty-three feet, between the Crozets and Kerguelen; the Novara thirty-six feet, in the Indian Ocean, where Lieutenant de Vaisseau, Paris, met with some of thirty-eight feet. The learned professor states that North Atlantic waves rarely exceed twenty-six feet in height, except in the Bay of Biscay, where Caldi has met them nearly forty feet high. Marsigli gives fifteen feet as the maximum height of waves in the Gulf of Lyons, and Smyth about thirty feet in the Gulf of Genoa. In vast oceans the waves are long and steep, whereas in the smaller seas they are short and comparatively low. Winds raise larger waves on a lee shore. Panes of glass two feet square and three-quarters inch thick have been driven in by blows of the sea, although eighty-six feet above high water on the Longships Lighthouse. A fog bell on the Bishop Rock was torn from its bracket, one hundred feet above high water, by a wave. An iron tower on the Calf Rock, eighty-six feet above the sea, was broken off by the action of the waves. In October, 1859, a wave is said to have overtopped the breakwater at Holyhead by one hundred feet; and, in falling, washed away the warning light and part of the solid structure itself. According to the formulas of Hagen and Lord Rayleigh and the observations of Scott Russell, Bazin and Stevenson, breakers occur when the depth of water is less than that of the wave. On the edge of such banks as those of Agulhas and Newfoundland a tremendous sea will be experienced, whereas on the bank the water is fairly smooth.

Various means have been devised for measuring the height and velocity of ocean waves, none of which is free from objection. When running before a heavy sea the wave velocity may be obtained by veering astern a cork fender, or other suitable float; then mark the time when it rises on a wave crest, and also when that crest passes the stern. With this, and the rate of sailing, the velocity is easily obtained. Height may be arrived at roughly by going aloft until the wave crest coincides with the direction of the horizon when the ship is in the hollow. The height of the wave is then equal to the height of observer's eye above the water line. Mr. Buchanan, of the Silvertown Telegraph Works, measured wave velocity by paying out a buoy on the crest of one wave, stopping it when on the next wave, and measuring the distance. Height was obtained by two leads; one on the crest, the other on the hollow. The Hon. Ralph Abercromby's method, employed by him on board the steamship Tongario, between the Cape and New Zealand, is probably a new departure. For measuring wave height he used an aneroid with very open scale and a chronograph measuring time to one-fifth of a second. An aneroid shows a decreased atmospheric pressure of about eleven hundredths of an inch for each 10 feet of increase in vertical height. Hence, if in a hollow his aneroid showed 29·200 in., and when on the wave crest 29·244 in., this difference of 0·044 in. of barometric pressure shows that the wave height was about 40 ft. Length and velocity were obtained by timing with chronograph the interval between two successive crests reaching the stern, or occupied by the first crest running the ship's length of 380 ft., the necessary correction for run being made. His maximum wave was 46 ft. high, 765 ft. long, moving at the rate of 47 miles an hour, with a period of 16½ seconds. Scoresby gave 600 ft. as the length of ocean waves, but this is too low an estimate, for Mr. Douglass, while building a lighthouse on the coast of Cornwall, measured some over 1,200 ft. from crest to crest; and Professor Thoulet asserts that Captain Chuden, of the Nautilus, met with waves to the southwest of Australia in 1879 which were 34 ft. high, and from 1,000 to 1,300 ft. long. It is said that the period of a wave, in seconds, is almost one-half the square root of its length in ft. Hence a wave 400 ft. long has a period of 10 seconds, and will pass a stationary ship in that interval of time. A wave 200 ft. long crosses the ocean at the rate of about 20 miles an hour.

The power of a wave hurling itself against an immovable object varies with the dimensions of the wave, its velocity, and with the depth. On the 25th of March, 1845, the celebrated engineer, Alan Stevenson, measured the wave force during a westerly gale at Skerryvore Rock, and found it to be no less than 6,083 pounds per square foot. A block of granite, weighing nearly 8 tons, has been displaced horizontally nearly 70 ft., while others weighing 6 to 13 tons have been placed on a higher level by 65 ft. than originally occupied, by wave force alone. At Wick a block of 1,350 tons weight was moved by the waves some 30 or 40 ft.

The influence of an ocean wave does not extend to a great depth, even near the land, so that perpetual tranquillity exists at the lowest depths, and the safety of telegraph cables resting on the bottom is assured in this respect. The brothers Weber have demonstrated experimentally that surface disturbance is felt at a depth equal to 350 times the wave height, but this result is deemed somewhat in excess of the truth. Sailors say that the sea is warmer when agitated by waves than when at rest, and Professor Tyndall agrees that their idea is theoretically correct. This heat, due to mechanical action, however, is immeasurable in the present state of our knowledge.

Ocean waves are due to friction of the wind upon the sea surface. Gentle ridges first appear, which gradually increase in height by the continuance of the force, until they become like rolling hills. Off the Cape of Good Hope a few ridges with their corresponding depressions will extend over a mile. These long waves are not so troublesome as shorter ones. It is a common mistake to suppose that the water itself advances with the wave. Only the pulsation moves onward, but the water remains rising and falling with pendulum motion, except a slight spray. Reaching a shallow bank the water does really go ahead, owing to retardation of the bottom. The form of the wave surface is known to mathematicians as trochoidal. Imagine a wheel rolling on a smooth sea surface, then every point in the wheel describes a trochoidal line, or, in common parlance, a cyloid. A point on the circumference of the wheel describes a common cyloid; if on a spoke, produced beyond the tire, it gives a curtate cycloid; if between the rim and center, a prolate cycloid; and an ocean wave may take any of these forms. It will be readily seen that the water particles do not move onward, but merely oscillate, by watching a water fowl, or dropping a chip over the quarter as a wave comes rolling along. Airy, Froude, Merrifield, Rankine, Stokes, and other eminent men of science, have written much on the subject of ocean waves, but mathematical treatment does not lend itself readily to popular explanation, and the most refined analysis may be thrown away where the data are too few or unreliable.
—*Nautical Magazine.*

THE UTILIZATION OF THE POWER OF OCEAN WAVES.

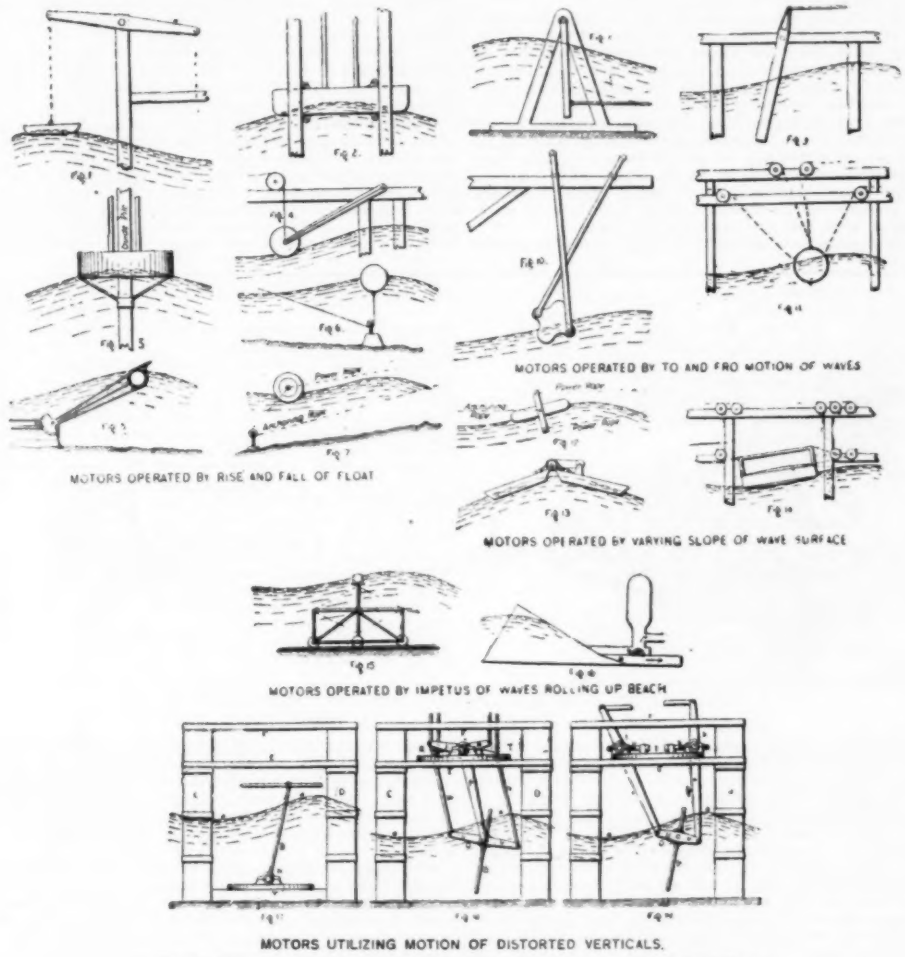
AT the recent meeting of the American Society of Mechanical Engineers at San Francisco, Mr. Albert W. Stahl, U.S.N., Asst. Naval Constructor, presented an exhaustive discussion of the subject above stated. The possibility of "harnessing the waves" has long been an attractive one to inventors, as the Patent Office records testify; but the subject has received little attention from engineers. We do not now recall any other paper of importance on the topic anywhere in technical literature.

Mr. Stahl's paper was really a fairly complete treatise on the subject of wave power and its utilization, being 56 pages in length. It opened with a discussion of the trochoidal theory of wave motion, which is the theory now generally accepted as a sufficiently close approximation to the actual motion of water waves. According to this theory each particle of water in a trochoidal wave moves in an elliptical orbit, whose major axis is horizontal, and the plane of which is vertical and perpendicular to the wave ridge or crest. The motion of the particle in the upper portion of its orbit is in the direction of advance or propagation of the wave; in the lower part of its orbit motion is in the opposite direction. The eccentricity of the ellipses depends on the ratio between the length of the wave and the depth of the water. When the depth is one-half the length of the wave or more, the ellipses cannot practically be distinguished from circles.

From his discussion of the form and method of motion of the wave, the author is enabled to deduce the following formula for the total energy of an indefinite series of deep sea waves, expressed in horse power per foot of breadth:

$$\text{H. P. per ft. breadth} = 0{\cdot}0329\ H^2 L\left(1 - 4{\cdot}935\ \frac{H^2}{L^2}\right)$$

in which H and L = the height and length of the wave respectively, expressed in feet. The following table is computed by this formula:


MOTORS OPERATED BY RISE AND FALL OF FLOAT
MOTORS OPERATED BY TO AND FRO MOTION OF WAVES
MOTORS OPERATED BY VARYING SLOPE OF WAVE SURFACE
MOTORS OPERATED BY IMPETUS OF WAVES ROLLING UP BEACH
MOTORS UTILIZING MOTION OF DISTORTED VERTICALS.

THE UTILIZATION OF THE POWER OF OCEAN WAVES.

TOTAL ENERGY OF DEEP-SEA WAVES IN TERMS OF HORSE POWER PER FOOT OF BREADTH.

Ratio of Length of Waves to Height of Waves.	Length of Waves in Feet.							
	25	50	75	100	150	200	300	400
50	0·04	0·23	0·64	1·31	3·62	7·43	20·46	42·01
45	0·05	0·29	0·79	1·62	4·47	9·18	25·30	51·94
40	0·06	0·36	1·00	2·05	5·65	11·59	31·95	65·58
35	0·08	0·47	1·30	2·68	7·37	15·14	41·72	85·63
30	0·12	0·64	1·77	3·64	10·02	20·57	56·70	116·38
25	0·16	0·90	2·49	5·23	14·40	29·56	80·85	167·22
20	0·25	1·44	3·96	8·13	21·79	45·98	126·70	260·08
15	0·42	2·33	6·97	14·31	39·43	80·94	223·06	457·89
10	0·98	5·53	15·24	31·29	86·22	177·00	487·75	1001·25
5	3·80	18·68	51·48	105·68	291·30	597·78	1647·31	3381·60

The above table gives the total energy, including both kinetic and potential, inherent in a regular series of waves. The figures are strictly correct for the trochoidal deep-sea wave with circular orbits only, though they give a close approximation for any nearly regular series of waves in deep water, and a fair approximation for waves in shallow water.

After concluding his discussion of the mathematical theory of wave motion, the author takes up the question of the practical utilization of wave energy, as follows:

Of the motions of the wave particles which may be utilized for power purposes, we find the following:

1. Vertical rise and fall of particles at and near the surface.
2. Horizontal to-and-fro motion of particles at and near the surface.
3. Varying slope of surface of wave.
4. Impetus of waves rolling up the beach in the form of breakers.
5. Motion of distorted verticals.

All of these motions, except the last one mentioned, have at various times been proposed to be utilized for power purposes; while no attempts seem to have been made to utilize this last mentioned motion, that of the distorted verticals, which seems the one by far most likely to give efficient results, as will be presently explained.

The most rational way of utilizing the vertical rise and fall of the particles at and near the surface, and the one almost invariably proposed, is by means of a heavy float. The float is either permitted to have a small amount of side motion, the extent of such motion being limited by the length of chains connecting the float to anchors, piles, or other fixed structures, or it is guided in a vertical straight line, or in the arc of a vertical circle. The float is usually hollow, being ballasted, if necessary, with rock or other heavy materials. It is usually rectangular and flat, or in the shape of a sphere, an ellipsoid, or a cylinder.

In Fig. 1 is shown a simple case, the float being secured to a rope which is attached to one end of a walking beam, the other end of the latter being connected by a second rope to suitable mechanism for utilizing the power. As the float rises on the wave, the slack of its rope is taken up by suitable ratchet arrangements, and when the wave falls, the weight of the float is available for the production of useful work.

In Fig. 2 the float is guided by guide rollers traveling along vertical piles. This float is provided with vertical straight racks, which transmit their motion to pinions located on the structure above. The racks being rigid, power can be taken off on both the up and down strokes, though, of course, no increase of power is thereby gained over the simple scheme of taking off the power during the down stroke only.

In Fig. 3 is shown a very simple device, a cylindrical float rising and falling on a central guide pile, the power being transmitted by means of vertical racks. A modification of this has the pump, which is operated by the rise and fall of the float, in the upper part of the guide pile itself, the object being to get all the principal parts as nearly as possible in line.

In Fig. 4 is shown an ellipsoidal float, held at one end of a frame, the other end of which is pivoted to a rigid structure at some point above the water. The motion of the float is transmitted by a rope to suitable pumping mechanism. This device is practically employed at some points on the Atlantic coast to pump salt water for street sprinkling purposes.

Fig. 5 shows a somewhat similar arrangement, the frame carrying the cylindrical float being pivoted below the surface of the water, and the shaft to which the frame is attached actuating suitable mechanism by means of a geared sector. This float is, in addition, provided with a curved lip to somewhat confine the water and thus get the full benefit of its momentum.

In Fig. 6 is shown a spherical float attached to a rope leading downward. The actual rise and fall of the float causes a corresponding motion of the rope, which leads through a sheave below to proper mechanism on shore.

The spherical float shown in Fig. 7 is anchored by means of a rope leading downward and through a sheave to the shore. As the float is forced upward by the rise of the wave, it is also compelled to approach the vertical line passing through the lower sheave, and thus causes a pull on the power rope, the power being thus transmitted by a sort of toggle joint arrangement, the efficiency of which, to say the least, is doubtful.

The main objection to floats operated by this vertical motion of the water may be briefly stated. In the first place, the quantity of power that can be obtained by a float covering any given area of water, and rising and falling through a certain distance, is directly proportional to the weight of such float, as the number of foot pounds of energy for each wave is simply the weight of the float in pounds multiplied by its rise or fall in feet.

With a wave of given height, then, the amount of power obtainable from such float can only be increased by increasing the weight of the latter. This weight may be increased in either of two ways: 1. By making the float heavier per square foot of water area covered, as by using heavier material, or by increasing the amount of ballast carried. 2. By keeping the weight per square foot unaltered, but increasing the area of water covered by the float. Either of these methods is, however, attended with a loss of efficiency. An increase in weight of float means an increase in submerged depth and in inertia; and the inertia of such heavy float could not be overcome with sufficient rapidity to cause it to rise to the whole height of the wave, thus decreasing its efficiency. If, on the other hand, the float be made light to reduce its inertia, the possible amount of power to be transmitted thereby would again be correspondingly decreased. Furthermore, as the area of water covered by such float is made greater, the particles of water in contact with different points of its length would be in different phases, so that the mean rise of such water would be less. Thus it is evident that if the float were just half as long as the wave, it would have a tilting motion, but no rise or fall as a whole whatever; and if it were longer than the wave, practically no power at all could be obtained thereby. But as the length of the waves varies from day to day, a float which would be fairly efficient on one day with a certain series of waves might be utterly inefficient with a series of waves of a different length some other day.

The next motion to be considered is the horizontal to and fro motion of particles at and near the surface. The simplest arrangement for utilizing this motion consists in suspending a vertical flat vane from some point above the water, the lower end of such vane dipping into the water to a certain limited depth and being actuated by the horizontal component of the motion of the particles at and near the surface. Such arrangements are shown in Figs. 8 and 9, the vane in the latter actuating suitable mechanism by means of a connecting rod attached to its prolongation above the point of support, while in the former it operates a submerged pump directly, by means of a connecting rod attached to its lower end.

That some power can be obtained by these devices is beyond question, but their efficiency is hampered by the fact that while at first sight it would seem that the amount of power thereby obtained would, with a given breadth of vane, be directly proportional to the depth of immersion of the lower end of the vane, yet it is evident that the deeper the immersion of the vane the less efficient the apparatus would be. For the vane has an angular motion about its point of support, its lower immersed end moving through a greater distance than the portion at the surface of the water. But we have above seen that the horizontal motion of the particles is greatest at the surface and becomes less as the respective particles are further below the surface. The relative motions of the upper and lower portions of the vane are thus exactly the reverse of the natural relative motions of the particles of water in contact with those portions; so that as such vane extends deeper into the water, it becomes less efficient. If the vane be extended to the bottom, its motion would be much reduced in the case of a shallow-water wave, and it would come to an absolute standstill in the case of the deep-sea wave. Instead of the vanes just described it has also been proposed to employ a float, rigidly secured to a long arm extending to and pivoted at some point of a fixed structure overhead or extending downward and pivoted at some point near the bottom of the water, but in each of these cases the utilization of the motion of the surface particles only is contemplated.

A somewhat more complicated arrangement is shown in Fig. 10, in which a peculiarly shaped float is supported by crossed suspension rods. The longitudinal concavities of the surface of the float are alleged to be "of substantially the form the waves assume as they approach the shore, so that the full force thereof is utilized better than if sharp corners were presented."

In Fig. 11 is shown an arrangement of a cylindrical float, suspended by a number of ropes attached to the float at such points as to utilize not only the rise and fall of the float, but also the horizontal to and fro motion of the same. The extreme motion of the float is limited by chains attached thereto, as shown.

The next motion to consider is that due to the varying slope of the wave. In Fig. 12 is shown a float which lies on the wave and changes its inclination to the horizontal in accordance with the varying slope of the wave. A rigid arm is firmly secured to the float, extending across the latter; and ropes attached to the upper and lower ends of this arm transmit the power to mechanism on the shore or on a suitable structure erected in the water near the shore, the float itself being prevented from moving shoreward by an anchoring rope. The objections to this scheme are twofold: In the first place, the curves in which the power ropes hang have different deflections according to the strain to which they are subjected. As the float becomes inclined by the action of the wave slope, the strain on one of the ropes increases, while that on the other decreases, the deflection of the former becoming less and that of the latter becoming greater; and the change in deflection corresponding to any increase in strain must be produced before the latter can be transmitted. The motion of the float must thus first take up a certain amount of slack in the rope, so as to decrease its deflection to that corresponding to the strain to be transmitted; but unless the waves were very steep, the motion of the float would probably hardly suffice to do more than take up this slack; and in such case no power, or at any rate very little power, would be transmitted. This defect in the arrangement could, however, be much lessened by placing the float much nearer the structure supporting the mechanism, so that shorter ropes or even rods could be employed for transmitting the power. But there is another and more vital objection. To obtain the largest amount of power from this arrangement, the float should be exactly half the length of the wave. But as the waves vary considerably in length from day to day, it follows that the float, while quite sufficient in waves to which its length was suited, would lose efficiency among larger waves, and come almost to a standstill among much shorter waves.

Somewhat akin to the above is the device proposed for employing the varying angle between two portions of the surface some distance apart in the direction of the length of the wave. It consists (Fig. 13) of two floats, preferably pontoons, containing the mechanism for utilizing the power, these floats being hinged together so as to be capable of motion relative to each other about a horizontal axis. As the floats ride on opposite sides of the crest of a wave, their outer ends are lower than their inner ends, while in the trough of a wave this condition is reversed. The angular motion of the floats relative to each other is employed to operate a ratchet wheel as shown, from which the power is transmitted to any suitable mechanism.

The difficulty with this device is also due to the varying length of the waves from day to day. It is evident that if the length of the floats or pontoons be too short in comparison with the length of the wave, the angle between them will be very slight and but little power will be obtained. On the other hand, if they are too long, the angle is again diminished and the same difficulty presents itself. Thus a pair of such pontoons, of proper lengths to give their greatest efficiency for a certain length of wave, would be much less efficient for a wave one half as long or double as long.

In Fig. 14 is shown an arrangement for utilizing all three of the motions above discussed. It consists of a rectangular float, surmounted by a framework rigidly attached to the same. A number of ropes are attached to various points of the float and of the framework as shown, leading over sheaves so placed that power will be transmitted not only by the rise and fall of the float, but by its tilting action on the slope of the wave, and by its horizontal to and fro motion. While superior, in some respects, to some of the simpler schemes above explained, it partakes of many of their disadvantages, and has the additional one of being somewhat more cumbersome and complicated.

Several radically distinct methods have been proposed for utilizing the impetus of breakers rolling up the beach. In Fig. 15 is shown a nearly vertical vane held in a framework which is provided with wheels at the bottom and with ropes leading to suitable mechanism on shore. These wheels run on rails laid down the slope of the beach, or may even run on the slope of the beach itself, if the latter be hard and smooth. As the breaker strikes this vane, it drives it rapidly up the slope of the beach, and the slack of the rope is taken up by suitable ratchets or other contrivances. As the water recedes, the weight of the vane and carriage causes the latter to run down the slope of the beach, and useful work may be performed by utilizing the pull on the rope. Some little difficulty would probably be experienced with this apparatus on account of the sand filling in along the track, which would probably finally result in throwing the apparatus off the track. It labors under the disadvantage that much of the inherent energy of the smooth waves is dissipated in the eddies of the breakers before it reaches the vane, and that the delivery of the energy of the breakers to the vane by what would practically be a sharp blow is naturally much less efficient than in cases where this transfer of energy is more gradual.

An entirely different method is shown in Fig. 16. The mass of water is allowed to enter a large strongly built chamber, which decreases in both height and width toward its shoreward end. At this end a non-return valve (*a*) is provided, beyond which is a closed chamber. In the top of the latter is the non-return valve (*b*), above which is an air chamber and a pipe leading to the water reservoir. When the wave enters the receiving chamber it has a certain velocity; and as the cross-sectional area of this chamber becomes less, the velocity of the water must increase until at the inner end it becomes sufficient to pass through the non-return valves (*a*) and (*b*), against the pressure due to the height of the water in the reservoir. While this apparatus has the advantage of simplicity and few working parts, it labors under the disadvantage that much of the energy of the waves is dissipated by the time they reach the apparatus. There is also much internal friction and great liability to filling up with sand. It has the further disadvantage of not being adjustable to rise and fall of the tide or the condition of the sea.

Taking up again the theory of wave motion, the author explains the "motion of distorted verticals" and why this motion is best suited for utilization as a source of power. In Figs. 17, 18 and 19 he shows three types of wave motors designed to utilize this motion, the motor consisting in each case of a thin vane, extending from above the surface of the water to near the bottom, and suspended in various ways, according to the depth of the water and the variations in magnitude and direction of the waves. It will be noted that these motors are designed to utilize both the to and fro motion of the vane as a whole and also its motion from a vertical plane to an inclination in either direction. The motor shown in Fig. 19 is, the author says, of the most general application. He describes the details of the mechanism, as follows:

In order to adjust the vane (B) about a vertical axis to suit the direction of the waves, there is provided in each of these arrangements a turn-table (T), which, by means of suitable mechanism, is turned and adjusted to any desired position, and properly secured after adjustment. The turn-table supports and carries with it the bearings, the vane, and all other necessary parts. This turn-table may be dispensed with when the contour of the coast or other influences cause a practically constant direction of the waves.

(C, D), etc., are firmly braced structures supporting the platforms or floors (E) and (F), the turn-table (T), and the vane (B). On these platforms or floors, or within the structures (C, D), etc., can be placed the pumping or other mechanism for transmitting, utilizing or storing the power derived from the waves by the vane, and the mechanism for adjusting and securing the turn-table. In practically building these structures it would probably be found best to make their lower portions closed, so as to be filled with concrete or other heavy material, while their upper portions would be open lattice-work, so as to interfere as little as possible with the movement of the wave.

The energy of the forward vibration of the distorted verticals is greater than that of their backward vibration; and the vane will thus not vibrate equally in both directions if the same resistance is opposed to it during both vibrations. The proper and regular working of the vane can be insured either by opposing a suitable smaller effective resistance to the motion of the vane during the backward than during the forward vibration, or by opposing to the forward vibration of the vane, in addition to the equal effective resistance opposing both vibrations, a suitable additional resistance so arranged as to yield up, during the backward vibration, the potential energy thereby stored up during the forward vibration. The former method simply requires that the amount of power derived from the vane on the forward and backward vibrations, respectively, is to be adjusted to correspond to the normal energy of the distorted verticals during these respective vibrations. The latter method is most simply carried out by the raising of a free weight or the extension or compression of a spring during the forward vibration, the potential energy of which is then allowed to assist the backward vibration. The irregularity of the vibrations which would be induced by a current can be rectified in a similar manner.

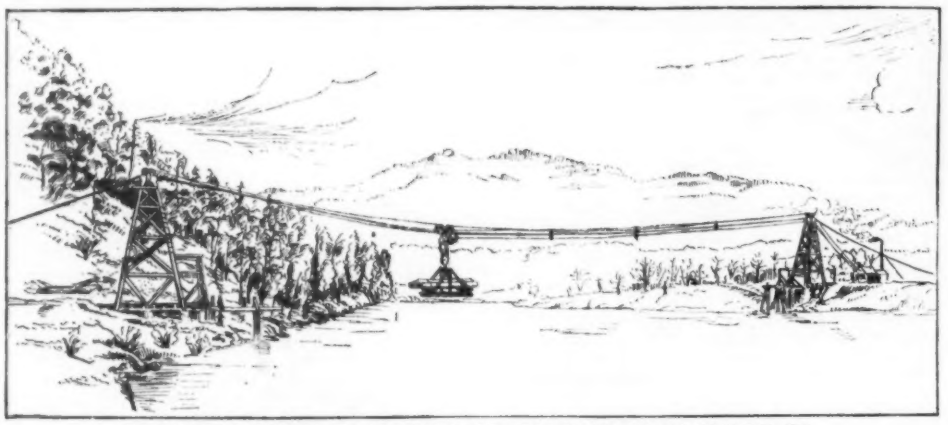
As the motion of these vanes, arranged as above proposed, conforms very closely to the natural movement of the distorted verticals, the elements of inefficiency which have been pointed out with reference to some of the previously described methods are very much reduced or even altogether absent. The action of the vane is more nearly akin to that of the piston of a steam engine, being driven forward and backward by the variations of the fluid pressure on its faces. Its weight does not affect the amount of energy, except as a slightly prejudical factor, which should be kept as low as possible. The vane is therefore made as light and thin as considerations of strength and rigidity will permit, thus reducing the loss of efficiency due to its inertia, and at the same time reducing to the least possible amount its interference with the normal structure and movement of the wave. A notable feature about these proposed vanes is that increase of immersion is accompanied by increase of efficiency; and this is a very important point of difference between them and certain other apparatus already described. The greatest efficiency for any particular series of waves will be obtained by letting the vane extend from the surface of the wave crest to the bottom of the water; and, provided the vane is long enough to reach to the top of the highest wave crest which it is desired to utilize, the efficiency of the apparatus will not be affected by variations in the magnitude of the waves. To accommodate themselves to variation in height of tide, most of the arrangements above discussed are raised and lowered bodily the required amount. Some of the floats are thus adjusted by simply shortening or lengthening the power ropes, which can readily be done; the floats that describe vertical arcs or circles adjust themselves by simply describing an arc which is higher up on their circle of motion; the floats describing horizontal arcs of circles and most of the vanes require their points of suspension or support to be adjustable in a vertical direction. The vanes proposed in this paper require no adjusting, being made of such length that they are long enough to reach the wave crests at high tide, while at low tide their upper ends simply project above the water.

To prevent damage to the apparatus in a heavy storm, some of the motors are located in inclosures, the gates of which may be closed in bad weather, and others are arranged to hoist out of the water altogether. But as the energy of the waves is very much greater during a storm than with an ordinary swell (see table of H. P. above given), it hardly seems wise to throw motors out of action at a time when they could develop the most power. We propose, therefore, to make our vanes of such length that they will reach to the top of the largest waves that can be faced with the strength of the vanes as constructed. When the size of the waves increases beyond this limit, and huge breakers come rolling in, the crests of the latter will be considerably above the upper ends of the vanes, so that the vanes will not be injured by the breaking of these crests; and as the motion of the water rapidly decreases below the surface, we consider that our proposed vanes may safely work in any weather, being entirely below the reach of the breaking crests of the waves in a heavy storm, while they project up through the wave crest in ordinary weather.

The author then takes up what is apparently the most difficult problem of all in connection with any considerable utilization of wave power, the necessity of providing a large storage of power for use during long-continued calms. After discussing compressed air tanks and storage batteries, he concludes that pumping water to an elevated reservoir is the system of power storage which offers on the whole the most advantages and seems best adapted for use in connection with a wave motor. As an example of what would be required in practice, he supposes a reservoir at an elevation of 340 ft. above the water wheel. If the water is used with an efficiency of 80 per cent., the discharge will be 2,122 cu. ft. per minute per horse power. If we assume that power is required for 10 hours daily, and that the reserve of power must be sufficient to last through a ten days' calm, then a reservoir to furnish 100 h. p. would have to be 20 ft. deep and 252 ft. square.

Although the author gives these figures to show the feasibility of the use of wave motors, they serve really to make very doubtful the use of wave motors for general power purposes, even under the conditions of dear fuel which exist on the Pacific slope. On the other hand, for uses where an intermittent action is admissible, such as pumping water for flushing sewers, street sprinkling, irrigation, drainage, etc., there seems to be considerable opportunities for the successful use of wave power.

In this connection it occurs to us that the irregularity which is the chief difficulty in utilizing wave power could be partially obviated by combining the use of wind and wave power. By erecting a windmill in connection with a wave motor, both storing power by pumping to an elevated reservoir, the probabilities of both motors being idle during any considerable time would be much reduced. It is true that calm seas and still air frequently accompany each other; but, on the other hand, the ocean is often fairly quiet when a strong breeze is blowing off-shore, and *vice versa*, a heavy swell is frequently rolling in when no wind is blowing.—*Engineering News.*



TRANSFER CABLE FOR RAILROAD CARS AT GLEN UNION, PA.

TRANSFER CABLE FOR RAILROAD CARS.*

As a fresh illustration of the advances made in the past few years in the overhead cable systems of hoisting and conveying, as applied to open-cut deep mining and quarrying, I would call attention to a further development of this system of transportation which has lately been put in operation in this State. A few miles above Williamsport, on the Susquehanna River, the Glen Union Lumber Company, of Pottsville, Pa., owned a large tract of valuable timber land, which they proposed to bring into the market. Unfortunately, this land is situated on the right bank of the river, while the railroad, the only available means of marketing the lumber, runs on the left bank. The river is about 850 feet wide at this place, and the cost of a bridge to carry the cars over was practically prohibitory, as it threatened to consume the profits

* Extract from paper read by E. J. Spilsbury, before American Institute of Mining Engineers.—*Railway Review.*

of the business for many years. Several plans for obviating the difficulty, such as a ferry transport or a floating bridge, were proposed; but these were considered impracticable by reason of the rapid floods and ice gorges to which this river is subject. The problem was then submitted to the writer, who proposed as a solution, and consequently erected, one of the Trenton Iron Company's cable hoists. This transfer has now been in successful operation for more than a year, and has thoroughly demonstrated the feasibility of the system for carrying loads of 20 or 30 tons over very long spans.

The work to be done was to take the loaded railroad cars from the tracks which brought them down to the river bank, and deliver them without unloading to the tracks of the Philadelphia and Erie Railroad on the opposite shore. The shortest span which could be obtained was 733 feet. The accompanying sketch shows the general construction. Two 70-foot towers were erected, one on each bank, and over the tops of these were stretched two steel cables, each two inches in diameter, each cable having a breaking strain of about 125 tons. In order to equalize the strains on these cables, and so keep them always parallel, they were made in one continuous length, the two loose ends being anchored rigidly on the railroad side of the river, and the bight at the other end passing round a 6-foot sheave, revolving in a shackle attached to the anchorage on the other bank. On these cables runs a carriage supported on four wheels, and moved back and forth by means of an endless cable one inch in diameter. In the lower part of this carriage are placed the hoisting sheaves, which, in conjunction with a large fall block, hoist the load vertically, high enough to free it from the tracks at each end, and from the river at its highest stage in the middle. A wrought iron lattice work cage, 36 feet in length, and fitted with tracks, receives the car at each end. The sag of the hauling ropes and also of the hoisting rope, which on so long a span would be very great, is taken up by a number of fall rope carriers of the Locke patent design. Indeed, the whole arrangement of carriage and fall blocks is only a modification of Locke's system to meet the special requirements of the case. The power required to operate the system is furnished by a 50-horse power, specially designed engine, built by the Lidgerwood Manufacturing Company. The total load carried is about 26 tons, including the cage and car; the estimated load of lumber being 12 tons. The trip across the river is made in about three minutes. The total cost of the whole structure completed was less than one-fifth the cost of a bridge, even of the lightest design.

During its operation last winter and spring no delays occurred from ice gorges or freshets. After it had been running for some months, however, it was found that the wear on the tread of the carriage wheels was very great. This was obviously due to the uneven surface of the ropes, which tended to cut a spiral thread on the grooves corresponding to the lay of the strands in the rope. Of course it would not do to make the wheels of harder material than the rope, since it is cheaper to replace them than it would be to wear out the rope; but at the same time, the cost of replacing the wheels threatened to lessen greatly the economy of the whole system. Hence, it has now been determined to replace the two main cables of the ordinary make by two of the smooth-coil Elliott locked rope cables, the use of which entirely obviates all this wear on the wheels. These ropes are now being manufactured, and I hope to present, at some future meeting, figures thoroughly demonstrating the great advantages of these ropes over all others for such purposes.

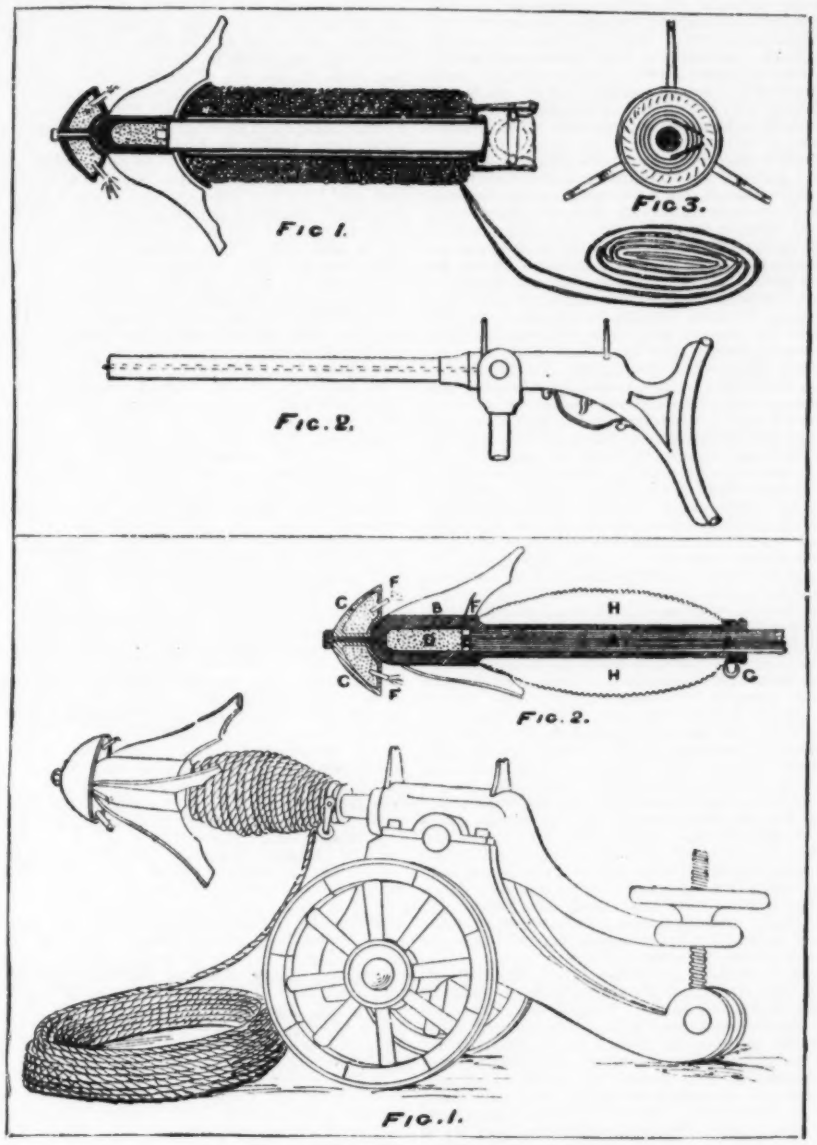
LIFE-SAVING DEVICES.*

IN the sketch of Mr. Carr's life line, gun, and bolt, Fig. 1 shows a section of the bolt with cap. Fig. 2 a side view of the gun without bolt, the dotted line indicating the firing needle; Fig. 3 is the rear end of bolt. The inventor says his gun is practically a solid bar or shaft pierced only by a small hole down its center to admit a firing needle actuated by a spring and trigger in the stock. The bolt or projectile fits outside the gun or shaft, and consists of a long, comparatively light tube with a thickened head or point, inside of which the firing cartridge is placed. This cartridge is provided with the usual central fire cap. Three large, widespread fins or wings are formed on the outside of the head, and these wings are set screw wise, so as to cause the bolt to spin in flight. Arrangements may be made for a flare to mark the flight of the bolt. A metal case is fitted outside the barrel of the bolt, and at the enlarged rear end shown in section two hollow rings are fitted one within the other, the outer ring being attached at two points to the case by pivots. Part of the outer ring is cut away to allow the cord to enter and pass round inside the inner ring, which thus acts as a pulley sheave for the cord or life line to work in.

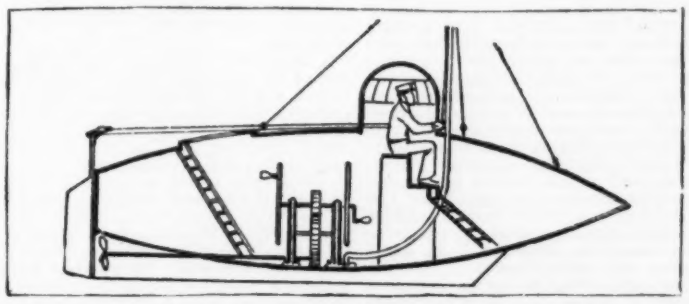
The line is threaded through the ring until both ends are of equal length, and both ends are brought back over the enlarged part of the case, and are carefully wound around the outside of the case until the desired quantity of line is on the bolt. The two ends of the rope are retained. The gun is rifled to cause the bolt to spin in the opposite direction to that in which the line is wound on. On reaching the shore the bolt head will bury itself in the ground. On the two lines being pulled tight, the rings which have been concealed in the enlarged part of the case change their position by moving on the two pivots and form a pulley sheave. The other sketch shows the gun and bolt for carrying a single line ashore. Fig. 1 shows the gun and bolt on a movable carriage. In Fig. 2, A is the firing needle; B, metal case; C, cap to contain flare; D, powder charge; E, wad; F, fuses; G, ring with swivel; H, section of coil of cord; I, anchor flukes of bolt.

Mr. W. Stevens has designed a means of communication for use when rockets and life boats are unavailing on account of the wind. He proposes to build a vessel such as is shown in the sketch (say of steel), self-righting and unsinkable, to be almost submerged, only a few inches in addition to the dome being out of water. It would be fitted with two propellers, capable of being worked either together or independently of each other. The mast would be a tube intended for signaling, and to supply air, which if necessary would be attached to the air pumps fixed to the winch which drives the propellers. The steersman would sit in the dome, of which the sides are to be made of strong, pliable, waterproof material, with sleeves like those of a coat, in which the steersman may place his arms, and thus be enabled to steer and hoist signals. Round the top glass squares would be placed, to enable him to see. The man would be secured by padded rings or straps to prevent him being hurt by the tossing of the waves.

A "Steeple-jack and Sailor" writes: For a period of twenty-five years I have been in a position to testify to the great uses to which a kite may be put. I have used a kite in my business to put gear over the tops of high factory chimneys, church steeples, and public buildings varying in height from 100 to 300 feet. I have always found that when the wind is strongest the kite answers the best. In some instances the chimneys or steeples have been surrounded with houses. I have then taken the kite to a meadow or waste piece of ground and raised it there; after which I have walked back with the kite line in my hand, and by that means I have guided the kite over the top of the shaft or steeple I wanted to climb. In some instances I have used as much as 2,000 feet of kite line. I am confident a kite can be used with the same success when a ship is stranded on a lee shore, provided the kite is of proper construction. Especially so in cases where a ship is wrecked on a shore where rocks and cliffs rise sheer out of the sea to a great height.—*London Daily Graphic.*



CARR'S LIFE LINE, GUN, AND BOLT.



UNSINKABLE BOAT TO CARRY MAN AND LINE.
(From a sketch by Mr. W. Stevens.)

COMPOSITE HELIOCHROMY.*

By F. E. IVES, of Philadelphia, Pa.

MOST people look to original discovery for the solution of photographic problems, and most photographical problems are solved by original discovery. There have been a few important exceptions to the rule. The production of the so-called half tone photographic block—the latest substitute for wood engraving—now grown to a very important industry, is one example. The first practical solution of this problem—a process which I patented in America, in 1881—was a purely mechanical invention, utilizing photographic processes already known. The so-called Woodburytype process is another purely mechanical invention, based upon well known photographic processes. The method of color photography, which I have named composite heliochromy, and which the French prefer to call photochromy, or composite photochromy, is also an invention, utilizing comparatively old and well known photographic processes. It is not a simple invention, but comprises several inventions by different men. The original suggestion was made twenty-seven years ago by her Majesty the Queen's painting master, Henry Collen. Briefly stated, Collen's idea was to make three negatives of an object, one by red light, one by yellow, one by blue—the so-called primary colors of Brewster—to print from each pair of these negatives (superposed as one) a transparent positive having the color (in the shadows) of the light that produced the third negative, and to superpose these colored positives on a white sur-

* Continued from SUPPLEMENT, No. 854, page 13642.

* A paper read before the Society of Arts, London, May 25, 1892.

face. A Baron Ransonnet, of Austria, is credited with the same suggestion in the same year, but I have not the reference.

It was not possible to carry out Collen's suggestion at that time, because there was no known process by which photographic plates could be made sensitive to the separate single colors only, and no photographic plates were sensitive enough to red and yellow to admit of the production of such negatives by exposure through selective color screens. Had it been possible to carry it out, the results must have been very imperfect, not only because the entire procedure is based upon a false and misleading theory of color, but also because superposing two negatives to act as one would double the intensity of such parts as represented white, gray, or pale colored objects, with the result that if the color prints were made to show all the details of the negatives, the finished heliochromes would show all bright colors as if mixed with equal parts of black pigment.

On November 23, 1868, Ducos Duhauron, of Paris, applied for a patent* for a process which differed from Collen's only in the manner of carrying out the same idea. Like Collen, he assumed that the spectrum is made up of three primary color rays and mixtures thereof. He said, "My procedure rests on the principle that the simple colors are limited to three—the red, the yellow, and the blue—the combination of which, in divers proportions, produces the infinite variety of shades in nature." Like Collen, he expected to solve the problem by superposing red, yellow, and blue prints from negatives made by yellow and blue, red and blue, and yellow and red light. But instead of using plates sensitive to simple colors only, he proposed to use plates sensitive to all colors, and to prevent the action of color rays not wanted by filtering them out with colored glasses placed in front of the sensitive plates; and, instead of superposing two negatives to act as one to make a color print from, he proposed to make two colors (that is, two-thirds of the spectrum) act to produce each negative, which amounts to the same thing. He proposed to make one negative through an "orange" screen, calculated to absorb the blue light and transmit the red and yellow; one through a "violet" screen, calculated to absorb the yellow light and transmit the red and blue; one through a "green" screen, calculated to absorb the red light and transmit the yellow and blue.

It was no more possible to carry out this idea in Duhauron's way in 1868 than to carry it out in Collen's way in 1865, although Duhauron having succeeded in making photographs by exposing ordinary photographic sensitive plates through glasses that were orange, green, and violet to the eye, imagined that he had succeeded in carrying it out. In reality, the photograph made through an "orange" screen must have been made chiefly by either the green, the yellow green, or the ultra-violet spectrum rays, as can readily be proved by photographing the spectrum itself through a bright orange screen (not an orange red one) on such a plate as he used. The photograph made through a "green" screen, that transmitted freely both the yellow and the blue rays, must have been made chiefly by the blue rays, and the photograph made through a "violet" screen must have been made without any action by the red rays, and with a great deal by the invisible ultra-violet rays.

Soon after Duhauron published the details of his process, Charles Cros, of Paris, published another modification of Collen's idea.† Like Collen, Cros proposed to make one negative by the action of red light, one by yellow, and one by blue; but by exposing the sensitive plates through red, yellow, and blue glasses, instead of employing plates sensitive to the single colors only. Instead of superposing the respective pairs of these negatives to make each color print, he proposed to make a green print from the negative made by red light, a violet print from the negative made by yellow light and an orange print from the negative made by blue light. Cros's plan was free from the defect of doubling intensity on those parts of the negatives representing pale or uncolored objects; but the advantage gained in this way would be lost again in the production of green-violet and orange colored prints.

The principle of color selection advocated by Duhauron is identical with that distinctly proposed by Collen, to whom alone the credit of the original invention appears to belong; but Duhauron and Cros, besides proposing a more reasonable plan for obtaining the negatives, further suggested that optical superposition of positive images from the three negatives might be substituted for the superposition of transparent colored prints.

On December 3, 1869, M. Poiree, of Paris, in a communication to the Photographic Society of France‡ suggested that better results might be had by making a greater number of negatives—a separate negative for each spectrum region.

In 1873, Dr. H. W. Vogel, of Berlin, discovered that bromide of silver can be made sensitive to the less refrangible spectrum rays by treatment with certain dyes; and this, with the subsequent discovery of other and better color sensitizers, supplied the means for carrying out either Collen's or Poiree's idea. Duhauron one of the first to avail himself of these discoveries, made some practical progress, and, in 1876, abandoned Brewster's color theory and patented a modified process,§ based upon the observation that, while there appeared to be "seven" principal spectrum colors, three coloring substances would "serve to express them." The coloring substances he named for this purpose are blue, carmine, and yellow; and he decided that, in order to make such a process reproduce the colors of nature, the negatives should still be made through orange, green, and violet glasses.

At this period, Duhauron's orange screen negatives were made on chlorophyl plates, and must have been made chiefly by the red spectrum rays. In 1878,‖ he announced that he had substituted eosine for chlorophyl, so that he must finally have made them chiefly by the greenish yellow spectrum rays. The significance of this fact has not been generally recognized. The production of three negatives, one through an "orange" screen, one through a "green" screen, and one through a "violet" screen, is a very indefinite procedure. A negative may be made through an "orange" screen chiefly by the action of red rays, or orange rays or yellow rays, or yellow-green rays, or green rays, or ultra-violet rays, according to the character and intensity of the "orange" color of the screen and the method of sensitizing the photographic plate for color. Duhauron, who never recognized the necessity of testing his process by photographing the spectrum itself, not only did not find out what it is necessary to do in order accurately to reproduce the natural colors, but at different times he did very different and inconsistent things without himself knowing that he did so. The facts can very readily be demonstrated by first showing the spectrum absorption of various "orange," "green," and "violet" screens, and then photographs of the spectrum which have been made on plates differently sensitized for color. I shall now proceed to demonstrate this point.

In 1879, Cros* also abandoned the idea that red, yellow, and blue are primary spectrum colors, but held that there are three primary spectrum colors and mixtures thereof, and that these primary colors are orange, green, and violet. Like Duhauron, he decided to make negatives through orange, green, and violet screens, and prints in blue, carmine, and yellow. Cros, like Duhauron, was apparently ignorant of the fact that very different negatives can be produced through one and the same screen, and he also allowed all of the invisible ultra-violet rays to act in producing the negative of the "violet" screen.

In 1885, Dr. H. W. Vogel† proposed to make the color prints with dyes identical in spectrum absorption with the color sensitizers employed in making the negatives. This does not amount to a principle of color selection, because the entire spectrum can be photographed on plates sensitized with dyes that cannot be combined to reproduce some colors, and even without any dye at all, by the use of suitable color screens.

Some time previous to 1889, I do not know the exact date, the Young-Helmholtz theory of color vision was first recognized in connection with this subject by Dr. F. Stolze, of Berlin.‡ He said: "Although the colors correspond with certain external processes in nature, there is also no doubt that color as such is nothing objective, but a subjective sensation, based upon the peculiar irritation of the visual nerves by those external proceedings. We can, therefore, only hope to produce a picture in natural colors when we are enabled to reproduce upon the same the proceedings which furnish to us the color impression." "Thomas Young . . . assumes that there are three kinds of nerve fibers, sensible to red, green, and violet. Objective homogeneous light excites all three; but with red the first is excited strongly, the second and third weakly; with blue, the second and third moderately strong, the first weakly; with violet finally, the third strongly, and the first and second weakly. If all three kinds of nerves are equally strongly excited, the impression of white light will take place." Dr. Stolze suggested, but rather indefinitely, a procedure which, although not really representing the application of this theory, was more nearly consistent with it than were any of the older ones. The theory itself was defective as a basis of procedure, Clerk Maxwell having shown that the fundamental red sensation is not at all excited by the blue-green, blue and violet rays, the fundamental green sensation not at all by the red or violet rays, and the violet sensation not at all by the red, orange, or yellow rays.

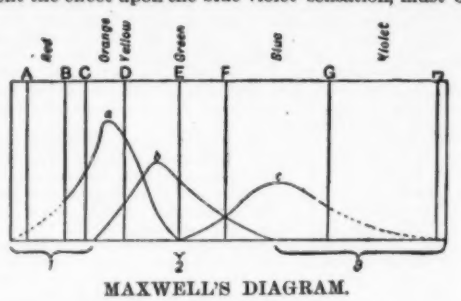
It was at this stage that, after ten years of experiment along the same lines as Duhauron, Cros, and Stolze, I myself made certain improvements and claimed the credit of bringing order out of chaos, by devising a procedure which not only recognizes the facts which support the modern color theory, but which definitely represents the application of that theory.

This process, although in a general way somewhat similar to those which preceded it, really represents a distinctly new principle, which is that of making three photographs by the action of light rays as they excite the three fundamental color sensations, and superposing these photographs by means of lights or in transparent pigments which suitably represent the corresponding fundamental color sensations.

In February, 1888, I demonstrated, at the Franklin Institute, Philadelphia,§ a process in which the color selection was according to a definite plan, and proved by photographing the spectrum itself, adjusting the color screens to obtain definite density curves in the spectrum negative. This was the first publication in which a really definite mode of procedure was indicated; but it was not until November of the same year ‖ that I demonstrated the method so modified as to definitely represent the application of the Young-Helmholtz color theory, in accordance with Maxwell's measurements of the relative power of different spectrum rays to excite the respective fundamental color sensations.

A little study of Maxwell's diagram, showing the result of his measurements, will show that the application of this new principle involves very important departures from the older methods of procedure. In this diagram, which I reproduce, 1, 2, 3 are spectrum colors which represent fundamental color sensations, because each excites one sensation only, and *a*, *b*, *c* are curves showing the relative power of different spectrum rays to excite the respective fundamental color sensations.

The first remarkable fact to be gathered from the study of this diagram is that the rays which represent a fundamental color sensation are in no case the ones that most powerfully excite that sensation. The red sensation is excited by all the spectrum rays from red to green, but most powerfully by the orange; and the negative to represent the effect upon the fundamental red sensation must, therefore, be made, not through a red glass, or by the red rays, but by the joint action (in definite proportions) of the red, orange, yellow, and yellow-green spectrum rays. The negative, to represent the effect upon the green sensation, must be made by the joint action of the orange, yellow, yellow-green, and green-blue spectrum rays, in proportion to their power to excite that sensation. The negative, to represent the effect upon the blue-violet sensation, must be



MAXWELL'S DIAGRAM.

made by the joint action of the blue-green, blue, and violet spectrum rays, in proportion to their power to excite that sensation.

By photometric measurement of the density curve of a spectrum negative, the relative amount of action by the different spectrum rays may be found. It is, therefore, only necessary, in order to secure action by different rays in any definite proportions, to use such a combination of sensitive plate and color screen as will yield a spectrum negative having a density curve corresponding to the graphic curve representing such proportionate action.

Sensitive plates and color screens that will yield three negatives of the spectrum, having intensity curves like the three graphic curves in Maxwell's diagram, will produce a permanent photographic record of the effect of light from any object upon the three fundamental color sensations. This can most readily be accomplished (with separate plates) by exposing a cyanine-stained rapid gelatine bromide plate through a double screen of aniline yellow and chrysoidine orange, of suitable intensity, for the red sensation; a commercial "orthochromatic" plate through a screen of "brilliant" (aniline) yellow, of suitable intensity, for the green sensation; and an ordinary gelatine bromide plate through a very thin piece of plane polished green glass for the blue-violet sensation. The screens that will secure the same results all on one kind of plate are far more complicated and difficult of adjustment; but any one who possesses a photospectrograph and a good assortment of coal tar dyes can, by the exercise of some skill and ingenuity, make the adjustments for himself.

The set of three photographs of any object, made as I have indicated, of course show no color whatever; but they contain, in a permanent form, such a graphic record of the natural colors that, in order to reproduce them to the eye, it is only necessary to superpose the three positive images, either upon a screen or upon the retina of the eye—the one representing the red sensation with pure red light, the one representing the green sensation with pure green light, and the one representing the blue-violet sensation with blue-violet light. The blending of the three images will excite exactly the same sensations as the light coming directly to the eye from the object itself. The synthesis can also be made with superposed transparent color prints, and this is the plan which has received the most attention, although the simplicity of *optical* superposition commends it to scientists, and is really more convincing to everybody.

Both Duhauron and Cros had the idea of synthesis by optical superposition as well as by color prints, but neither of them succeeded in carrying out the idea practically. Superposition by triple optical lantern projection was first carried out successfully by me, in my demonstration at the Franklin Institute, Philadelphia, in February, 1888, showing a landscape photographed from nature. I employed a single lantern box, having three optical systems close together, with a triple lime light jet, and the three positives mounted side by side in a single wooden frame, behind red, green, and blue glasses. A considerable variety of subjects were shown with the same lantern in November of the same year, when I first clearly stated and demonstrated the principle which represents the application of the Young-Helmholtz-Maxwell color theory.

The first workable plan of optical superposition other than by lantern projection was devised by Antoine Hippolyte Cros, brother of Charles Cros, and patented in 1887. In this device, the three pictures are arranged relatively to each other like the steps of a staircase, and by means of a peculiar system of mirrors, some of which are attached to the face of a rapidly revolving wheel, with open spaces between them, the different pictures are seen by the eye in one optical plane, in such rapid succession that they appear like a single picture, with colors blended. The same device, which is a very ingenious one, was to be used also for making the negatives; but it is so clumsy, so troublesome, by reason of the necessity for providing means to keep the mirrors in motion, and includes such an extremely narrow angle of view, that I believe it has no practical value.

Both Duhauron and Cros taught that synthesis by optical superposition should be accomplished with the same mixtures of light rays that acted to produce the different negatives. The picture made through an orange screen was to be seen by the light transmitted by the same, or an exactly similar screen, and so on.

I hope I have made it clear that such a procedure is quite irrational, in view of the facts which support the Young-Helmholtz-Maxwell color theory. The photograph made by the joint action of various different colors of spectrum rays must be seen by rays of one color only. Spectrum rays of various colors excite one fundamental sensation, but only spectrum rays of one single color will serve to represent that fundamental sensation.

I have taken particular pains to emphasize this fact in every paper I have published upon this subject, but have not yet succeeded in impressing it upon the minds of the French writers, who continue to assert that my procedure does not differ in any essential particular from that indicated by Duhauron and Cros. I think that this one difference alone is of vital importance.

* Class xviii., sec. 3, serial No. 83,061.

† Described in *Photographic News*, October 8, 1869, p. 483.

‡ *British Journal of Photography*, 1870, p. 26.

§ British patent, July 22, 1876, No. 2,973.

‖ "Traite Pratique de Photographie des Couleurs," Paris, 1878; *Photographic News*, 1878, p. 115.

* Bulletin of the French Photographic Society, 1879, p. 23.

† *Annalen der Physik* (N. S.), xxvii., p. 130; *Phot. News*, 1887, p. 568.

‡ *Anthony's Photographic Bulletin* (N. S.), 1888, pp. 516, 555, 568, 647, 678.

§ *Journal of the Franklin Institute*, cxxv., 345.

‖ *Journal of the Franklin Institute*, Jan., 1889.

The application of the Young-Helmholtz-Maxwell theory involves important changes from the older methods, not only in the negative process, and in the synthesis by optical superposition, but also in the production of permanent color prints. Theoretical considerations alone led me to conclude that a transparent color print from either negative could be made to perform exactly the same function that the positive transparency from the same negative performs in the synthesis of triple lantern projection, and a simple experiment with the triple lantern confirms my conclusions.

The white disk that we obtain in screen projection by mixing the red, green, and blue-violet lights corresponds to the white paper which may form the basis of a permanent color print heliochrome. When we insert the positive of the red sensation in its place in the lantern, its shadows cut off the red light, leaving the disk still white except in the shadows, where there remains only a mixture of the other two lights, green and blue violet; a transparent print from the same negative performs the same function when laid upon the white paper, provided that its shadows also cut off the rays that excite the fundamental red sensation, but freely transmit the green and blue violet. I have found that a coal tar dye, sold as "thio blue A," absorbs those rays which excite the fundamental red sensation, but freely transmits the green and blue violet; a Woodburytype process print in this color fulfills the requirement for a permanent print to represent (by transparency) the effect upon the fundamental red sensation. By a similar process, I have found that fuchsine fulfills the requirement for making a print to represent the green sensation, and aniline yellow the print for the blue violet sensation. It is true, as I have already pointed out, that these permanent color print heliochromes will show a slight degradation of color in ordinary white light, but they should exactly reproduce the natural colors when viewed in a white light produced by mixing the red, green, and blue-violet spectrum rays.

The theoretical conditions of success have, therefore, been realized for the negative process, and for all three methods of synthesis.

But there is another aspect of this subject which, from a practical and commercial point of view, is quite as important as that of realizing the theoretical conditions of success. I am of the opinion that, however perfect results this process could be made to give, it would not be reasonable to expect it to be commercially successful, so long as complicated by the necessity for making three separate photographic negatives and three separate photographic color prints, in order to obtain a single reproduction in colors. Such a complicated procedure might be carried out successfully by experts, dealing with such subjects as paintings or similar art objects, but would not be available for landscape photography, or in the hands of amateurs.

The only way to make the process simple and reliable enough to be available generally is to reduce the number of negatives to one, and dispense with the color print process altogether. This I have accomplished by the invention of a camera that makes the three pictures on a single plate, by one exposure from one point of view, and a device, which I have named the heliochromoscope, that optically recombines the triple black and white photograph into a single photograph reproducing the natural colors. With this camera (about the size of a kodak) and the heliochromoscope (the size of a hand stereoscope), the reproduction of the natural color by photography is not only made practically available, but reduced to the simplicity of stereoscopic photography.

I wonder if people are prepared to realize the full significance of this fact. The hope of producing color *prints* by a direct process is calculated to discredit the value of an equally simple method that accomplishes substantially the same result in a different way. I said, "substantially the same result," but, in a way, it is a better result, because it is quite impossible that any colored picture, with its distracting surroundings and surface reflections, should ever produce such a perfect illusion of nature itself as we may obtain with this little instrument, consisting of several small mirrors, two of them transparent, placed at certain angles with reference to the photograph, and inclosed in a box. If the heliochromoscope was merely a box for seeing photographs in colors, it might be regarded with indifference; but I hold that it is as far from being merely that as the phonograph is from being merely a device for making a noise by turning a handle. It is capable of accomplishing for us, in the reproduction of colors, more than the phonograph accomplishes for us in the reproduction of sounds, because the illusion is more perfect. I quite believe that the writer who, in a recent article in *The Speaker*, described the heliochromoscope as a toy, comparable to the kaleidoscope, would have been capable, under similar circumstances, of comparing the phonograph to a baby's tin rattle.

I have also tried to simplify and perfect the color print process. The employment of the new triple camera, making one operation take the place of three, is one step in that direction. The use of the dyes I have mentioned, corresponding to the colors produced in screen demonstration, is another. The production of a single print instead of three, cutting the images apart only when ready to be dyed, is another. Experiment with the Woodburytype process is another. The Woodburytype process offers the vitally important advantage for reproduction in large numbers that, having found experimentally the right amount of dye required in each of the three color prints, an indefinite number can be made without any variation. It will be available for the commercial production of lantern slides. These appear to be real advances; but, after all, the further complication and mechanical difficulties of carrying out the print-making process render it comparatively unsatisfactory up to the present time—and the value of composite heliochromy must be estimated, for the present, on the basis of its application to the photographic reproduction of the natural colors by optical superposition.

If the heliochromoscope is the only solution of the problem that is sufficiently simple to be practicable for general introduction, there is, nevertheless, a field for the application of the method of color projection for lecture illustration. Here, also, we escape the complication and mechanical difficulties of color printing, and obtain results which are permanent as far as the color record goes, and which can be shown to many people at one time. It will be necessary, however, to employ the arc electric light in order to project landscape views at night as perfectly as they have already been projected by sunlight. The value of the method cannot be fully demonstrated with the lime light.

In conclusion, I would like to say another word to emphasize the fact, which I think is quite sufficiently demonstrated in the heliochromoscope, that, although we are not able to make photographs in natural colors of exactly the kind that people have been looking for, we have, nevertheless, found a true solution of the problem of reproducing the natural colors by photography, as remarkable in its results as the telephone or phonograph, more perfect in the illusion of nature than would be possible in colored pictures, and almost as easy to realize as stereoscopic photography. It seems to me that this is an advance so great that it should finally break down the prejudice against the idea of composite heliochromy which has grown out of the long series of failures of unscientific, complicated and impractical methods. With no more operations than are required to make an ordinary photograph, we now make a photograph that, as we are able to see it, reproduces nature itself, light, shade and color.

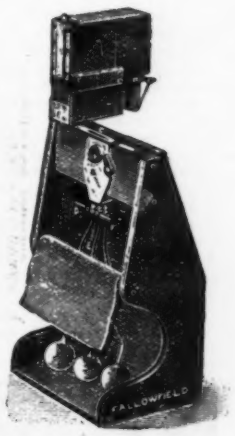
A POCKET CHANGING BAG.

THOSE who are out for the day with the camera know the usefulness of a changing bag. The one here shown is an English device, sold at $2. It weighs only

a few ounces, and packs into a very small compass. The bag fastens round the head, allowing the eyes and lower part of the face to go inside the bag. There are two sleeve holes through which the plates are passed. By the aid of elastic these are made to fit tightly round the wrist.

NIEVSKY'S FERROTYPE DRY PLATE CAMERA.

THIS apparatus, just introduced in London by Mr. Fallowfield, may be regarded as an outcome of the penny in the slot photographic machine; but, instead of the arrangement being altogether automatic, it is worked by hand. No dark room is required, and it is intended for use with the ferrotype dry plates mentioned in another place. The camera, with its developing attachment, is represented by the accompanying cut. The movable piece at the top of the apparatus is a camera, the upper part of which is a reservoir for plates, and the lower part is the true camera with a flap shutter to the lens. The action of slide marked A brings the plate down from the reservoir to the camera, and after exposure, the camera is brought



over slot C, and the plate drops into a tank where the developer, fixing solution, and washing water are forced up in succession from the rubber reservoirs or balls shown. Finally the plate is taken out by a dipper. With this apparatus it becomes possible to turn out a ferrotype print every few minutes with an apparatus which, all told, does not equal a cubic foot in bulk, and a new industry in penny portraits may rise out of its use.—*Photographic Work.*

PHOTOGRAPHING FLOWERS.

No worker in photography has produced more beautiful photographic studies of flowers than Mr. John Carpenter, of Clapton. His method of procedure is as follows: He works in a greenhouse, setting up a dark background, and using Edwards' isochromatic plates, and develops with pyro and ammonia.

WAVE PROPAGATION OF MAGNETISM.

By JOHN TROWBRIDGE.*

VARIOUS attempts have been made to discover a wave propagation of magnetism along bars of iron or around rings of this metal.† The ordinary method of investigation has been to subject the iron to alternating currents of a certain frequency, and to search for nodes along the extent of the bar or ring. The search has been conducted by employing small secondary coils of wire connected with a ballistic galvanometer or with telephones.

I have lately examined this question with a new instrument which I have termed a phasemeter, and which seems to me to be of great use in the subject of alternating currents. It consists of an application of Lissajous' method of studying the vibration of tuning forks to two telephones which take the place of the tuning forks. On the diaphragm of each telephone is affixed a mirror; and the axes of the telephones are so turned that the excursions of a spot of light, reflected from both the mirrors of the telephones, represent the figure produced by a combination of two motions at right angles to each other. In the telephone which I have employed, the diaphragms are about three inches in diameter and are clamped delicately around the edges upon their support by little screw clamps, which can be moved about until the diaphragm vibrates in unison with the alternating currents which are employed. Professor Eli W. Blake‡ has described a method of making the vibrations of a telephone diaphragm visible. And since I began to work upon this subject M. Wien§ has described an instrument which he terms an optical telephone, which he employs for the measurement of alternating currents. In his method a stylus connected with the center of the diaphragm touches a light mirror which is placed upon a flexible support, and thus the motions of the diaphragm are amplified. Great care must evidently be taken that the support of the mirror should move in unison with the stylus connected with the diaphragm. Professor Blake's method is an extremely sensitive one. For my purposes, however, I have found the method of clamping the diaphragm around its edges at suitable points sufficiently sensitive, and I have not been troubled by the vibration of supports or disturbances in the room where the instrument was set up. The two telephones can be mounted upon the same support, and the entire instrument can be comprised in a box a foot square. I have used as a source of light a Welsbach burner, which consists of a fine gauze of zirconium placed in the flame of a Bunsen burner. A tin chimney provided with a circular opening of about one half inch in diameter is placed over a glass chimney, and a cylinder of writing paper over the tin cylinder; a pin hole in the paper at the center of the orifice in the tin chimney enables one to obtain a point of light on a light ground. This light ground diminishes diffraction effects and enables one to see the cross wires of an observing telescope or microscope. With a lime light or electric light the difference of phase between branch circuits and main circuits through which alternating currents are pulsating can be shown to a large audience. On account of its application to the study of difference of phase in magnetic researches, I have termed the instrument a phasemeter. It is evident that it can be used to study the nodal lines of membranes and plates. For this purpose a plate or membrane provided with a mirror might be placed in front of a movable magnet containing at its end a coil of wire, and the vibrations of any membrane or thin plate could be compared with those of the diaphragm of a fixed and standard elephone.

I have also employed the instrument for studying differences in phase between branch circuits. That there are such differences of phase has been shown by Lord Rayleigh and others. This portion of my investigation I reserve for a subsequent paper.

The phasemeter permits of the study of the effect of different qualities of iron and steel in increasing the self-induction of, and therefore the impedance of, branch circuits; and it seems to me can be made of great use in the study of alternating current motors. It is well known that two or three electrodynamometers must be employed in the ordinary methods of determining change of phase. The phasemeter can be quickly employed and its adjustments are extremely simple. The application of this instrument to the question of magnetic waves is the subject of this paper. I have employed it both on rings and straight bars, laminated and solid. The ring I employed was three feet in diameter, and the diameter of its cross section was one half inch. Two large coils of coarse wire were slipped upon the ring, through which an alternating current could be passed. These coils could be separated or joined together, and by a commutator opposite poles or poles of the same name could be opposed. Two small coils of fine wire were also slipped upon the ring. Each of these small coils was connected with a telephone. The diaphragm of one telephone gave a horizontal line of light and the diaphragm of the other a vertical line, the combination of the two amplitudes giving a straight line, an ellipse, or a circle.

On placing one of the small coils at a fixed point on the ring on one side of one of the large coils and the other small coil between the two large coils, I examined the distribution of magnetism between the coils when the same poles or opposite poles were opposed to each other. A preliminary experiment in which the two small fine coils were on the same side of one of the large coils gave me no indication of nodes, or change of phase.

When, however, one coil was placed in the manner I have described between the two coils, and one on the opposite side of either of the coils, the following phenomena, which are sufficiently obvious, were observed. With a current of 2,500 alternations per minute, an ellipse was seen in the phasemeter when the coils were at an equal distance from the ends of either of the large coils. When poles of the same name were opposed to each other, this ellipse changed from an ellipse with its major axis inclined to the right to an ellipse

* Communicated by the author.

† Dr. Harold Whiting, Proc. American Academy of Arts and Sciences, p. 14 (1881); F. T. Trouton, 'Nature,' November, 1891.

‡ American Journal of Science, vol. xvi. (1878).

§ *Ann. der Physik und Chemie*, No. 12 (1891).

with this axis inclined to the left or the reverse, thus indicating a difference of phase of 180°.

At the central point on the iron between the two poles of the same name, the small coil placed there indicated no lines of force threaded through it, and consequently the telephone connected with this coil gave no amplitude, and a line of light either horizontal or vertical was given by the other telephone. When poles produced by the current in the large coils were of opposite sign, there was no appreciable change of phase produced by moving one of the small coils on the iron between these poles; only the amplitude of the diaphragm of the telephone connected with it changed.

The reason of the change of phase in the first case is obvious. In the case of two poles of the same sign which are opposed, the lines of force are threaded through the coil in one direction on one side of the middle point of the iron between the coils and in the opposite direction on the other side of this middle point. With poles of opposite sign opposed, the lines of force are threaded in the same direction, in whichever way the small coil is moved between these poles. The same phenomena can be observed on straight bars. An interesting manner of showing the change of phase produced by the opposition of poles of the same or contrary sign is to place one of the small coils on the core of a large coil at one end of this latter coil, and to place the other small coil on a small rod of iron or steel and to bring this rod with its coil near one end of the core of the large coil and afterward to the other end. The change of phase of the ellipses is readily shown, and is evidently due to the threading of the lines of force by induction through the small coils in the same or in opposite directions.

If an incandescent lamp of about one candle power is connected with one of the small coils, and the coil is placed on the iron ring between poles of the same name, the lamp will not glow; but on changing the poles, so that two of opposite sign shall be opposed, the lamp immediately glows. This point, however, cannot be called a true nodal point, and I failed to find any other. Although it is probably true that the most distant molecule of the iron quivered under the periodic alternations of magnetism to which it was subjected, yet there was no wave motion along the iron ring. Just as a distant molecule might have responded quickly to the first application of heat to the ring, there is no true wave motion in the propagation of the heat. It seems to me that the propagation of magnetic disturbances produced by forced oscillations on iron bars is closely analogous to the propagation of heat over these bars, and that each molecule of the iron swings under the directive moment of the magnetic field somewhat like a pendulum in molasses.

Instead of the formula

$$\frac{d^2u}{dt^2} + k\frac{du}{dt} + n^2u = \mathrm{E}\cos pt,$$

we have

$$\frac{d^2u}{dt^2} + k\frac{du}{dt} + n^2u = 0.$$

The curve of distribution of magnetism on the ring can be made to agree closely with an exponential form, which is evidently the solution of the second of the above equations.

The projection of the ellipses on a screen makes a very interesting lecture experiment.

To ascertain whether changes of phase could be detected between the inner portions of a thick iron core subjected to alternating magnetic impulses and the outside of this core, I placed one of the coils of the phasemeter in a channel which was turned about the center of a core of iron, the diameter of the curve being 2½ inches. Another coil with its center coinciding with the center of the embedded coil was slipped on the outside of the core: no changes of phase could be observed between the inner portions of the iron core and the outside portions. When an armature was placed over the embedded coil, thus completely closing it in iron, hardly any lines of force were threaded through it. They were diverted to the surface of the iron core. Here we had the case of Thomson's marine galvanometer, and the amplitude shown by the telephone diaphragm connected with the embedded coil was reduced to almost nothing. When, however, the armature which extended over the entire cross section of the core was removed and an armature was employed which extended the iron which passed through the center of the embedded coil beyond the limits of the ends of the thick core, the lines of magnetic force were brought down from the surface of the iron and made to thread themselves through the embedded coil. Properly chosen armatures can be made to closely resemble arrangements of lenses, bringing magnetic lines into bundles or spreading them. An incandescent lamp can thus be made to glow when it is connected with a coil embedded in iron, by diverting the lines of magnetic induction through it with suitable armatures. To illustrate the distribution of the lines of force about an electromagnet, one can employ the phasemeter to advantage. By reducing the diameter of the iron ring on which the coils I have described are slipped, so that a sufficient number of lines of force are threaded from the north pole to the south pole of one of the large coils, one can show that an incandescent lamp can be lighted even when it is outside the coil in a plane perpendicular to the axis of one of the large coils and passing through its center. It is evident that there would be no induction through the coil if the iron did not make a magnetic circuit.

The experiments I have described were conducted with an alternating machine giving currents of the period of 2,500 to 5,000 a minute. Doubling the rate of alternation only produced changes in amplitude.

Dr. Harold Whiting, in the paper I have cited, could find no true nodes in the propagation of magnetism along bars, and my instrument also shows none; and my conclusion is that which I have already given, namely, that the propagation of magnetic induction in iron and steel is expressed by the equation of motion of molecular magnets in a resisting medium rather than by the equation of a wave motion.—*Philosophical Magazine.*

THE THEATROPHONE.

OF all the inventions with which we have been endowed by that marvelous fairy that we name electricity, there is none that has found so many applications as the telephone. The papers are constantly making known some new use of it, and as surfeited as we are at this end of a century that has witnessed so beautiful discoveries, the mind remains confounded before the progress made with an apparatus of which the name not longer than thirty years ago caused scientists to shrug their shoulders, and brought a smile to the countenance even of the most convinced believers in the omnipotence of electricity, without speaking of the use of the telephone in the army, where, as experience has many times demonstrated, it renders inestimable services during maneuvers, and will prove no less useful in the field. We now see in the United States, in several very extensive parishes, that the faithful for whom it would be impossible to go to the temple can, thanks to the telephone, follow the celebration of the offices without leaving the house. Moreover, at the Birmingham Hospital, the friends or relatives of the sick correspond with them by telephone, and this permits of getting news from them directly without running any risk of infection. Further, the firemen now carry with them an apparatus by means of which, on their arrival at a fire, they can put themselves in communication with the central station and ask for the necessary help. Very recently, an inventor has proposed on analogous system that would permit trains remaining in distress between two stations to instantly make known the situation to the neighboring station. We shall speak, as a remembrancer only, of the services rendered by the telephone in the government departments, railway stations, etc., and of the numerous applications that it has found in medicine and surgery. The space reserved for this article would not suffice for the complete enumeration of such uses.

Our object at present is to present to our readers one of the most recent innovations founded upon the use of the telephone, viz., the theatrophone, the installation of which in Paris, scarcely two years old, has, in this short interval of time, taken a development which is very remarkable. Every one knows these little apparatus (Fig. 4) which are now to be found in the large hotels, cafes, restaurants, theater vestibules, etc., which proceed both from the telephone and the automatic distributer, and which, through the introduction of a 50 centime piece into a slot, permit of listening for five minutes to a *morceau* that is being played upon the stage of a theater and the title of which is given in a wicket in front of the apparatus. During the listening, if an intermission occurs, the name of the first theater is replaced by another, and the auditor is immediately put in communication with another stage. If an intermission occurs at a given moment in all the theaters, the apparatus will allow a piano or a song to be heard, so that in no case will the auditor run the risk of giving his money for nothing.

This result is obtained as follows: The central station of the Theatrophone Company (Fig. 1) is connected with secondary stations placed in the theaters. Each of these secondary stations is provided with batteries, bobbins, call apparatus, commutators, etc., and communicates with a series of microphones placed upon the stage on each side of the prompter's box. The cables that connect these stations with the central station end at a distributing board to which are likewise fixed the cables that run to the theatrophones and a certain number that run to the central telephone office of the Opera Avenue. The role of these latter will shortly be explained.

The cables of the theatrophone are formed of three conductors; two of these twisted together serve for the transmission of the music, and the third actuates the alarm. The same cable serves for several apparatus. Thus, to mention but one example, the line of the Continental Hotel serves a total of twelve apparatus distributed between the Rhine, Dominici, London, Continental, St. James, Albion, Windsor, Wagram and Brighton Hotels. The apparatus are not necessarily fixed. It suffices to arrange collectors along the line of the cable and to connect these with

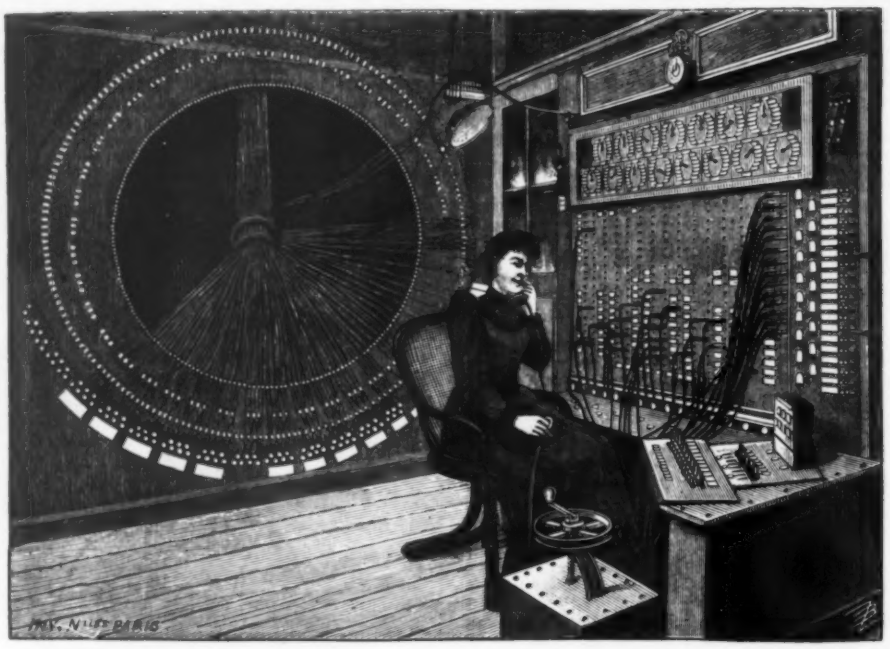


FIG. 1.—GENERAL VIEW OF THE CENTRAL STATION OF THE THEATROPHONE COMPANY.

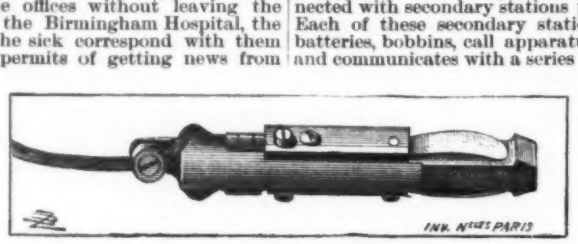


FIG. 2.—DETAILS OF A PLUG.

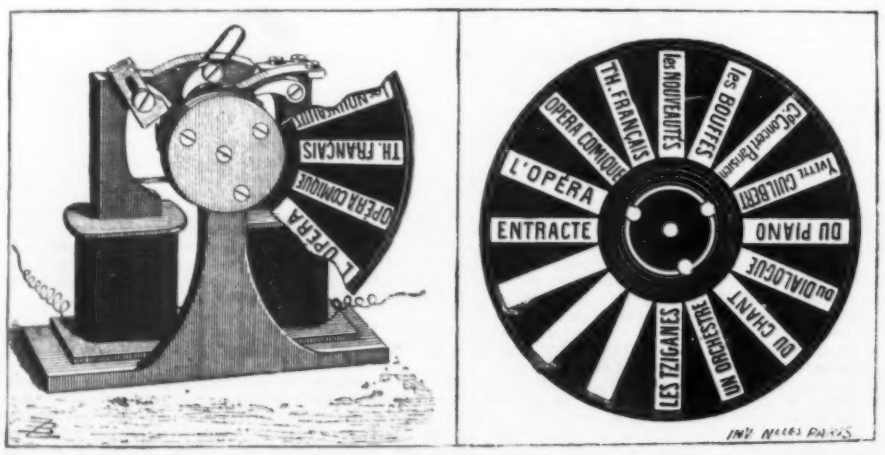


FIG. 3.—MECHANISM OF THE ALARM.

the apparatus when it is desired to make them operate. Such is the case with the Café de la Paix, which has four movable apparatus and sixty collectors. When the apparatus is stationary, the signaling is easily effected by means of the third conductor, as we have said. In the case of movable apparatus it is impossible to operate in the same way. Fixed alarms, independent of the theatrophone, are then arranged at certain definite points and well in view. The theatrophone is provided with a button, which permits of re-establishing the synchronism between its indications and those of the fixed alarms controlled by the central station.

At present the company has installed in Paris 100 apparatus, grouped upon eleven different lines.

But, aside from the theatrophone service, the company has also a certain number of subscribers, that is to say private individuals, who, through the payment of a fixed amount, have the right to a certain number of listenings at home. It is to this service that is devoted the third group of cables that end at the distributing board already mentioned. These persons are necessarily subscribers also of the telephone. It follows that, in order to allow them to use the theatrophone, the operator of the Opera office will merely have to connect the subscriber's line with the one coming from the central station of the theatrophone whose number is indicated by the operator of this latter station.

After passing into the distributing board, all the cables end at a switch board, which does not differ sensibly from those used by the administration of telephones. However, as the number of lines to be served here is not so large, it has been possible to give the spring jacks a rectangular form and to adopt much larger movable plugs having the advantage that all their parts are metallic externally, thus greatly facilitating surveillance and repairs. Fig. 2 represents one of these plugs.

Referring to the switch board, it will be seen that the operator has at her right, within reach of her hand, a crank that serves to operate the alarms of the various lines of the theatrophones. A repeating telegraph placed at the top of the board, and through which passes the third wire of the cable, indicates the alarm has operated properly. By reason of the somewhat large size of the card board disk that carries the names of the various theaters (Fig. 3), the inventors have been led to adopt for the mechanism of the alarm the arrangement shown in the same figure. Owing to the stop seen to the left, each revolution of the crank causes the ratchet wheel supporting the disk to advance by one tooth only. The motion is therefore rendered sufficiently slow to prevent the disk acting like a fly wheel and skipping several divisions at a time.

The small levers placed to the right of the board serve, some of them, for sending the current into the circuits of the theatrophones and others into the subscribers' lines. The operator having introduced a plug with flexible cord into the spring jack corresponding to the Opera, for example, and the other extremity into the jack carrying the number of the subscriber whom it is desired to connect with this theater, has only to depress the lever of this same number in order to establish a communication. As each theater cable is formed of six double conductors all ending at the board, it follows that it is possible to connect the same theater with several lines at once. A telephone permits the operator to turn at every instant to the theater line and verify the operation. If she discovers any irregularity, she at once notifies the theater. Finally, every subscriber's cable, on leaving the switch board, passes into a commutator, which permits of sending the current into a measuring apparatus and of thus verifying the resistance of the line as often as may be desired. Such is the installation that very recently permitted the Lord Mayor of London to give some guests an opportunity of listening to the opera, and the prefect of Nantes to hear the latest popular songs without having to submit himself to the smoky atmosphere of a concert hall. Let us hope that the theatrophone will soon be completed by the theatrophote, and that the eye will be able to follow the actors at the same time that the ear hears their words.—*Les Inventions Nouvelles.*

FIG. 4.—GENERAL VIEW OF A THEATROPHONE.

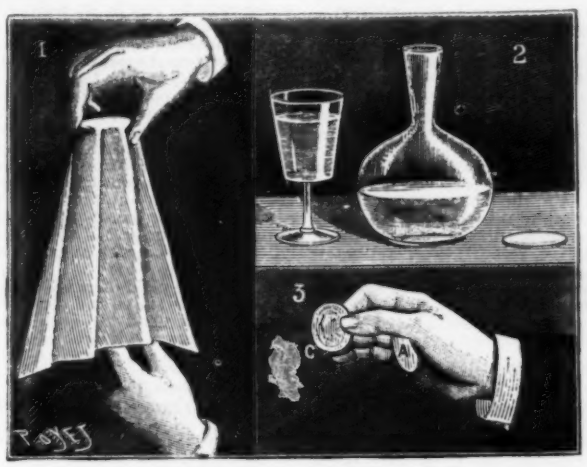
THE DISSOLVING COIN.

BORROW a silver dollar, and have it marked, so that it can be identified. Ask some one to hold the coin horizontally between the thumb and forefinger of the right hand within the folds of a silk handkerchief, and over a glass full of water held in the left hand, Fig. 1. Your assistant's two hands being thus occupied, you will have no sort of indiscretion to fear. Stepping back a few feet, direct your assistant to let the coin drop; and the impact against the bottom of the glass will be heard by the entire assemblage. When the handkerchief is raised the coin is no longer in the glass, but has made its way to your hand or to the pocket of a spectator. Let it be examined, and it will be found to be really the coin that has been previously marked.

In order to perform this trick it is necessary to have a disk of glass of the same diameter as a silver dollar (Fig. 2).

Hide this disk, A (Fig. 3), in the palm of your right hand, turned toward you. This will not prevent you from holding the coin that has been confided to you between the thumb and forefinger of the same hand. While your hand is concealed by the handkerchief in which it is thought that you placed the coin, you shift the latter and give the assistant the glass disk to hold, by the edge, of course, and not by the flat surface, so that the substitution that you have made cannot be perceived by the touch.

After the trick has been performed, do not be afraid to let the person who has held the coin, and who is thoroughly astonished, examine the glass and its contents at his leisure. The glass disk is entirely invisible in the water, and if, as it is well to do, you have taken care to select a glass whose bottom is perfectly plane and of the same diameter as the disk (Fig. 2), the latter will remain adherent to the glass even when it is inverted in order to empty the water in order to prove once more to the spectators that it contains nothing but clear water.—*La Nature.*



DISAPPEARANCE OF A SILVER DOLLAR.

THE RAPID TESTING OF AGRICULTURAL PHOSPHATES.

MESSRS. CHARLES and E. Deiss have communicated the following process to the Industrial Society of Marseilles. Ten grammes of substance are treated with hot sulphuric acid, which converts the basic into acid or monobasic phosphates. The liquid is filtered and carbonate of soda added until there is an alkaline reaction. All the acid phosphates are decomposed. After boiling to remove carbonic acid, which dissolves a little phosphate of lime, the liquid is filtered and the alkaline filtrate saturated with dilute sulphuric acid to convert the neutral or basic sodium phosphate into acid phosphate.

The solution is again boiled and allowed to cool, and two or three drops of methyl orange (Paisier No. 5) and some drops of phenol phthalein are added.

The liquid becomes pink from the action of the acid on the methyl orange. A standard solution of caustic soda is then added until the disappearance of the pink tint, the liquid being of a pale yellow shade. Normal caustic soda solution (31 grms. Na_2O per liter) is then added, until the red coloration of the phenol phthalein is produced. Each cubic centimeter of this solution required represents 1·47 of phosphoric acid.

The theory of this process is that methyl orange retakes its yellow color as soon as the sulphuric acid is saturated, acid phosphate of soda having no action upon it; as soon as the acid phosphate is converted into neutral, the phenol phthalein becomes colored red, as observed by Joly, and hence the amount of phosphoric acid can easily be determined. To determine the absorbable phosphoric acid a second quantity of 10 grammes is treated with ammonium citrate or acetic acid, to remove the soluble phosphate, and then proceeding as before the amount of absorbable acid is got by difference.

By treating the precipitate produced by sodium carbonate with concentrated acetic acid, the soluble basic phosphate of lime is removed and the phosphoric acid present as phosphate of iron and aluminum can then be determined.

The determination of phosphoric acid by this means has the advantage, according to the authors, of possessing the rapidity and precision of an alkalimetric titration.—*L'Engrais.*

PURIFICATION OF WATER BY FREEZING.

By WM. P. MASON.

THE old notion that water completely purifies itself by freezing has by no means died out, and even after Pruden's able report on the contaminated condition of much of the public ice supply, we find educated people collecting ice from sources so polluted as to be beyond question unfit to furnish drinking water. A somewhat aggravated case of this kind having presented itself, the following experiments were undertaken to outline the relation existing between an ice and the water from which it is frozen. The materials employed for experiment were mixed with ordinary tap water. The weights given are in grammes per 100 cb. c. of water.

	Total Residue from 100 c. c.	Loss on Ignition Volatile and Organic Matter	Inorganic Residue	Per cent. of the Mineral Matter Originally in the Water yet Remaining in the Ice	Per cent. of Organic and Volatile Matter of the Water yet Remaining in the Ice
100 c. c. urine diluted to 10 litres	·0285	·0070	·0215		
Ice from same	·0023	·0022	·0001	0·46	31·43
500 c.c. urine diluted to 10 litres	·1320	·0469	·0911		
Ice from same	·0389	·0213	·0176	19·32	45·41
10 c.c. urine in 10 litres of water	·0112	·0047	·0065		
Ice from same	·0040	·0018	·0022	33·84	38·21
100 c. c. glycerine diluted to ten litres	·7951	·7911	·0040		
Ice from same	·1042	·1005	·0037	17·50	12·70
50 gms. sugar dissolved in 10 litres water	4932	·4860	·0072		
Ice from same	·1373	·1360	·0013	18·05	27·98
50 gms. NaCl in 10 litres water	·5013	0	·5013		
Ice from same	·1449	0	·1449	28·9	
10 litres of water tinted with indigo	·0399	·0336	·0063		
Ice from same	·0027	·0027			8·03
10 litres H_2O, with a little egg albumen—*i.e.*, ½ of that in one egg	·0163	·0119	·0044		
Ice from same	·0038	·0031	·0007	15·91	26·05
10 gms. Na_2CO_3 in 10 litres of water	·0907	·0038	·0869		
Ice from same	·0180	·0025	·0155	17·83	65·78
10 gms. sugar in 10 litres of water	1045	·0996	·0049		
Ice from same	·0118	·0100	·0018	36·73	10·04
10 gms. oxalic acid in 10 litres of water	·0129	·0067	·0062		
Ice from same	·0037	·0022	·0015	24·19	32·82
10 gms. glycerine in 10 litres of water	·0187	·0140	·1047		
Ice from same	·0028	·0010	·0018	38·30	7·14
Troy City supply	·0092	·0035	·0057		
Ice from same	·0010	·0010	trace	0	28·5
Very hard spring water	·0540	0	·0540		
Ice from same	·0045	0	·0045	8·3	
Water from Erie Canal, where public ice supply is taken	·0112	·0033	·0079		
Ice from above locality used for public supply	·0067	·0025	·0042	53·2	75·7

Dilute sulphuric acid was prepared of a strength = 0·3280 gramme H_2SO_4 per liter. The ice from same when melted retained H_2SO_4 corresponding to 0·0390 gramme per liter. Ice retained 11·89 per cent. of the H_2SO_4 in the water.

From the foregoing it will be observed that organic impurity is more liable than mineral matter to pass into ice, and, inasmuch as the organic impurity is the more objectionable of the two, the distinction is important. It will be noticed that the waters con-

taining sewage and urine formed ices of the greatest organic percentages.

Of the fifteen waters containing organic impurity, the percentages of such impurity retained by the ice varied from 7·14 per cent. to 75·75 per cent., with an average of 34·3 per cent.; while of the eighteen waters holding mineral impurity, the ices formed therefrom retained from a trace to 53·20 per cent. of such impurity, with an average of 21·2 per cent.—*Chem. Tr. Jour.*

PHOSPHOROUS OXIDE.

By A. E. TUTTON.

IN addition to the well-known pentoxide formed when phosphorus is burned in air or oxygen, a second oxide of phosphorus has long been surmised to exist. Very little, however, has hitherto been known concerning this second oxide. It is usually described in current chemical literature as a white amorphous powder of the composition P_2O_3, very voluminous, somewhat more volatile and more readily fusible than the pentoxide P_2O_5, and instantly dissolved with great rise of temperature by water, with formation of phosphorous acid.

During the last three years an investigation has been carried out in the laboratory of the Royal College of Science by Prof. Thorpe and the writer, which has resulted in showing that phosphorous oxide is a substance possessing properties entirely different from these. Full details of this work have recently been laid before the Chemical Society, but a short account of the manner in which the pure oxide has been isolated in quantity, of its somewhat remarkable properties, and of a few of its more important reactions, may, perhaps, not be uninteresting to readers of *Nature*.

PROPERTIES OF PHOSPHOROUS OXIDE.

Before describing the mode of preparing the oxide, it will be advisable to briefly indicate the external appearance and essential properties of the substance. Phosphorous oxide is not an amorphous powder, but at temperatures not exceeding 22° C. a pure white crystalline solid, compact and heavy, soft and wax-like in character. Its most striking property is the ease with which it melts, the warmth of the hand which holds the vessel containing it being more than sufficient to convert it to the liquid state. Its melting point is 22·5° C. Hence, upon a warm summer's day or when placed in a warm room, it takes the form of a clear, colorless liquid, very mobile, but somewhat heavy. It is best preserved in sealed glass tubes, the air of which has been replaced before the introduction of the oxide by carbon dioxide or nitrogen, in order to avoid the action of the oxygen contained in air, which rapidly converts phosphorous oxide to phosphoric oxide. When a tube containing the liquid oxide is cooled by immersing it in cold water or allowing it to stand in a room of ordinary temperature (17°–20° C.) the oxide rapidly resolidifies in a most beautiful manner, large crystals shooting out in all directions until the whole is one compact mass of interlacing crystals. When the liquid is heated in a distillation flask previously filled with one of the indifferent gases, carbon dioxide or nitrogen, it soon commences to boil, and the vapor condenses in the condensing tube and the unchanged oxide runs down into the receiver placed to intercept it in the form of liquid, which eventually condenses to the solid again. Its boiling point is 173·1° C.

The vapor of phosphorous oxide possesses a very characteristic odor, which appears to be the same as that so noticeable about a lucifer match manufactory. Owing to its great volatility, both the solid and the liquid are constantly vaporizing, even at the ordinary temperature, and hence the odor is always strongly marked in their neighborhood.

Phosphorous oxide may also be obtained by spontaneous evaporation *in vacuo* in beautiful large isolated crystals, probably belonging to the monoclinic system, which are quite colorless and transparent, and very highly refractive; crystals have frequently been obtained in this manner an inch in length and broad and thick in proportion, showing numerous prism and pyramid faces. Similar crystals are obtained when solutions of the oxide in carbon bisulphide, chloroform, ether or benzene, in which the substance readily dissolves, are evaporated out of contact with the air.

Instead of reacting with violence with water, as appears to have been generally supposed, phosphorous oxide is comparatively indifferent to that liquid, only dissolving with great slowness. If a few drops of the liquefied oxide are dropped into water of about the same temperature, they at once fall to the bottom of the tube, and the two liquids do not mix. If the water is at the ordinary temperature, the oxide solidifies as it falls to the bottom.

A few grammes of the oxide, either liquid or solid, require several hours for complete solution. The solution contains phosphorous acid. When phosphorous oxide is warmed with water to a temperature just below 100°, a violent reaction of an entirely different nature occurs; spontaneously inflammable phosphureted hydrogen is evolved with a loud explosion, and red phosphorus and phosphoric acid are largely formed.

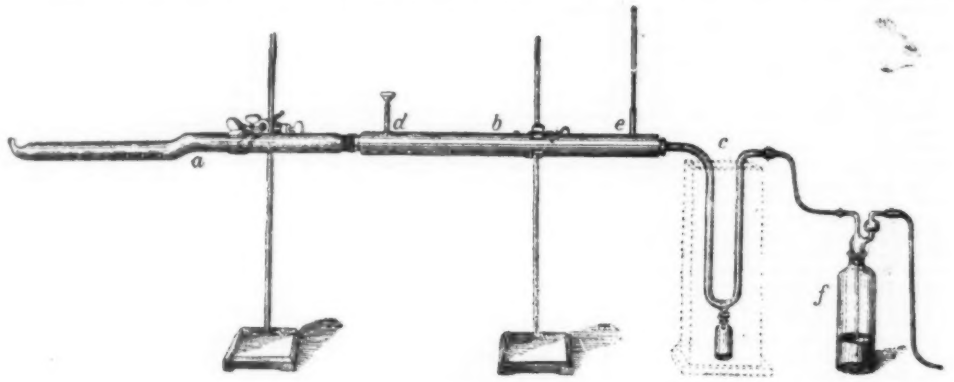
PREPARATION OF PHOSPHOROUS OXIDE.

It is quite a mistake to suppose that when phosphorus is burned in a combustion tube in a *slow* current of air the lower oxide, and not phosphorous pentoxide, is produced. Scarcely a trace of phosphorous oxide is obtained under these circumstances, the white amorphous powder deposited being pentoxide. It is only when the current is at all rapid that phosphorous oxide commences to be formed. Its advent is at once apparent, as it crystallizes all along the upper portion of the horizontal combustion tube in beautiful feathery crystals, which at once melt if the finger is laid upon the exterior of the tube, while the pentoxide settles out along the bottom of the tube. After several less successful attempts to devise a method of producing these volatile crystals in larger quantity, and of separating them entirely from the pentoxide, a method has at length been found by which as much as twenty-eight grammes of the pure oxide have been obtained in an experiment of five hours' duration.

Two sticks of phosphorus are cut into pieces about an inch and a half long, and placed in a glass tube bent into the shape shown at *a* in the figure, so as to retain the phosphorus when in the melted condition. The tube should be of 1½ in. bore, and should be made from *new* soft glass tubing, which is quite hard enough to stand the heat of burning phosphorus. The tube is drawn out somewhat, but quite open, at the end where the air is to be admitted, and at the other is narrowed slightly, so as to fit into the condenser, *b*, a tight joint being obtained by means of a caoutchouc ring or a little bicycle cement. This condenser, *b*, is intended to retain the phosphorous pentoxide and any free phosphorus produced during the combustion, and is maintained at such a temperature that the phosphorous oxide passes uncondensed through it. It is therefore constructed of brass instead of glass, and is made double, that is, with an outer jacket also of brass, so that the space between the two brass tubes may be filled with water of the required temperature. This water may be run in by means of a funnel through a small vertical tube, *d*, a second such tube, *e*, serving for the introduction of a thermometer. The size of condenser found most convenient is 2 ft. in length, and the inner brass tube has a bore of 25 millimeters. At the end of the condenser furthest from the phosphorus, a plug of glass wool about half an inch long is inserted, the fibers being arranged transversely as much as possible; such a plug forms an excellent means of filtering off any pentoxide which would otherwise escape into the phosphorous oxide condenser, especially after the first few minutes of the combustion, when its meshes become loosely filled with porous pentoxide. Directly into the end of the brass condenser fits tightly, by means of a cork annulus, the large glass U-tube condenser, *c*, in which the phosphorous oxide is condensed. The yield of oxide appears to depend somewhat upon the shape and dimensions of this condenser, that found most advantageous having the shape shown in the diagram, a height of 35 centimeters from the bottom of the bend, and an internal bore of 14 millimeters.

A short vertical tube is fused on at the bend, and passes down into a bottle, into which the oxide may be melted at the end of each combustion. The whole condenser is surrounded by a tall wooden box, indicated by dotted lines in the figure, containing pounded ice. To the end of the condenser is attached a wash bottle, *f*, containing sulphuric acid, which serves to prevent access of moisture to the oxide condensed in the U-tube, and also able to measure the rate of the current of air drawn through the apparatus by the water pump.

In making a preparation, as soon as the phosphorus,



APPARATUS EMPLOYED FOR THE PREPARATION OF PHOSPHOROUS OXIDE.

dried by blotting paper, has been introduced and the tube containing it attached to the brass condenser, which at first is quite cold, the phosphorus is warmed to the igniting point and the pump set working by turning on the water tap to which it is firmly attached. After about ten or fifteen minutes, crystals begin to make their appearance in the U-tube; the oxide then rapidly collects in the form of a waxy mass. The best refrigerator for the U-tube is pounded ice; if salt is mixed with it, the oxide condenses so rapidly in the first cooled portion of the condenser as to form a bridge and stop the operation until it is melted down. When nearly half of the phosphorus is burned the brass condenser is warmed by pouring in water heated to about 70°–80° C., and the condenser is maintained at this temperature until about three-quarters of the phosphorus has been burned, when the operation is stopped by slowly turning off the water working the pump.

When phosphorus is burned under these conditions, three oxides are produced; more or less of the red suboxide P_4O is always deposited in the immediate neighborhood of the burning phosphorus, a certain amount of pentoxide is formed and retained in the glass tube beyond the seat of combustion and in the brass condenser, and phosphorous oxide is produced in large quantity, and, being considerably more volatile, is carried forward to the cooled condenser, any which may be deposited in the brass condenser during the earlier stages of the combustion being carried along into the U-tube in the current of escaping nitrogen when the warm water is introduced into the brass condenser.

Scarcely a trace of pentoxide escapes through the glass wool filtering plug, the product in the U-tube being almost pure phosphorous oxide. In the course of five hours three such charges of phosphorus may be burned out and the total phosphorous oxide produced, which should amount to at least twenty grammes, can be condensed in the same U-tube, the product from each charge being melted down into the bottle so as to prevent choking of the tube. In order to free the product from any traces of impurity, it should be distilled in a slow current of carbon dioxide, when it condenses in the receiving tube as an absolutely clear liquid which soon solidifies to a snow-white mass of crystals. The tube should be at once sealed and, for a reason which will be found under the *Action of Light*, kept in the dark.

MOLECULAR COMPOSITION OF PHOSPHOROUS OXIDE.

Quantitative analysis of the substance whose properties and mode of preparation have just been described of course yields numbers which agree with the empirical formula P_2O_3. But as the oxide is volatile it was of the first importance to determine its vapor density, with the view of obtaining information regarding its molecular weight. This determination was the more interesting from the fact that Prof. Victor Meyer had previously found that the analogous oxides of arsenic and antimony gave vapor densities corresponding to the double molecular formulæ As_4O_6 and Sb_4O_6, and also from the fact that the molecule of phosphorus itself is found to contain four atoms. The vapor density was determined by Hoffmann's well-known method in the Torricellian vacuum at the temperatures of boiling amyl alcohol (132°), oil of turpentine (159°), and aniline (184°). The numbers obtained from several such determinations are in perfect accordance with the molecular weight corresponding to the double formula P_4O_6. This result has been fully confirmed by a determination of the molecular weight by the totally different method of Raoult, which depends upon the degree of lowering of the freezing point of a solvent, in this case benzene, by the introduction of a small quantity of the substance undergoing investigation.

Hence phosphorous oxide must be symbolized by the formula P_4O_6 and not P_2O_3, phosphorus thus resembling its family relatives arsenic and antimony in the nature of its lower combination with oxygen.

PHYSICAL PROPERTIES OF PHOSPHOROUS OXIDE.

The specific gravity of the solid oxide at 21° C., compared with water at 4°, is 2·135, and that of the liquid oxide at 24·8° is 1·9358. Hence there is about 9 per per cent. of contraction upon the passage of the liquid into the solid state.

A somewhat interesting result has been obtained from the determination of the specific volume, that is, the number obtained by dividing the molecular weight by the density at the boiling point. The actual density, of course, cannot be experimentally determined at the temperature of ebullition, but by making a careful determination of the rate of expansion and knowing the density very precisely at some lower temperature, the density at the boiling point can be calculated. The value thus found for the specific volume was 130·2. Now, phosphorus is known to possess two specific volumes; one in the state of combination (as determined from its halogen derivatives) and which is somewhere about 25·3, and another when in the free state, which is approximately 20·9.

Oxygen, too, is usually supposed to have two values, one of 7·8 when it is linked to two different atoms, single linkage as it is termed, and another of 12·2 when doubly linked to one and the same atom of another element. If we subtract six times 7·8, that is deduct the specific volume due to six atoms of oxygen, from the specific volume 130·2 of phosphorous oxide, we arrive at the number 83·4 for four atoms of phosphorus, or 20·9 for that of one atom. If any of the oxygen atoms were doubly linked the number would be considerably less than 20·9, hence this number represents the greatest possible value of the phosphorus in phosphorous oxide.

It would appear, therefore, that the phosphorus in phosphorous oxide possesses the same specific volume as free phosphorus itself, a result of interest in view of the fact revealed by the determinations of molecular weight that there are four atoms of phosphorus in the molecule of the oxide, just as there are in the molecule of free phosphorus itself.

The liquid oxide, considering that it contains such a highly refractive substance as phosphorus, possesses a remarkably low power of refracting light. Its refractive index at 27·4° C. is only 1·5349 for the red line of lithium and 1·5614 for the blue hydrogen line, G. Not only is the refractive index of phosphorus (2·0677 for the red hydrogen line, C) enormously reduced by its combination with oxygen, but the length of the spectrum is reduced to about one-fifth.

ACTION OF LIGHT.

Phosphorous oxide, in the white, wax-like solid form in which it usually condenses after distillation, is remarkably sensitive to light. Ten minutes' exposure to bright sunshine suffices to turn it red, and after half an hour it is rendered quite dark red. The red substance which is formed is the red modification of phosphorus, but even after several months' exposure the amount produced has never been found to exceed 1 per cent. of the weight of the oxide. The beautiful isolated crystals obtained by sublimation *in vacuo* appear to be unaffected by light, but it is a curious fact that if one of them is melted by the warmth of the hand, and the liquid globule afterward suddenly cooled to the wax-like form, the latter becomes red on exposure to daylight. Whether the reddening is due to the conversion of small quantities of admixed yellow phosphorus into red phosphorus, or to the decomposition of the waxy form of the oxide by light, there is not yet sufficient data to determine.

ACTION OF HEAT.

It has been seen that the oxide boils without decom-

position at 173°. It may be heated in a closed tube to considerably over 200° without change. It commences to decompose, however, between 210° and 250°, becoming turbid from the separation of solid decomposition products, one of which is free phosphorus, which becomes more and more deeply colored, until at 300° it is quite red. At about 400° the oxide is totally decomposed into solid products, consisting of both yellow and red phosphorus and phosphorous pentoxide. Occasionally, when only the lower half of the tube has been immersed in the heating bath, the formation of crystals has been observed in the cooler portion of the tube, which appear to be identical with some described in a previous communication to the Chemical Society which gave numbers on analysis agreeing with the formula P_2O_4, and which yielded a solution with water capable of reducing mercuric chloride to calomel. Hence the final decomposition by heat may be expressed by the equation

$$5P_4O_6 = 6P_2O_5 + 8P,$$

but under suitable circumstances the intermediate formation of the tetroxide may occur according to the equation

$$2P_4O_6 = 3P_2O_4 + 2P.$$

ACTION OF OXYGEN.

Phosphorous oxide takes up oxygen spontaneously at the ordinary temperature. It is probable, however, that the oxygen only reacts in the cold with the vapor. For if a small quantity of the oxide is placed at the bottom of a glass tube closed at one end and previously filled with oxygen, and the tube is sealed and left in the dark in an upright position, the oxide is gradually converted to a voluminous mass of pentoxide, which is deposited in a most beautiful manner in regular annuli all up the tube to the very top. When the oxide is placed in contact with oxygen in an apparatus in which the pressure can be rapidly diminished, the oxidation is seen to be accompanied by a phosphorescent glow, flickering up and down throughout the whole inclosed space, similar to that which occurs under the same circumstances with phosphorus itself. Moreover, this phenomenon is observed with the purest specimens distilled *in vacuo*. If the temperature is increased, the phosphorescence is brought about at pressures near the atmospheric, and if it is raised to 70° C., phosphorescence gives place to actual combustion, which, however, may be at once reduced to mere phosphorescence by diminishing the pressure. If the oxide is thrown into oxygen warmed to about 50°, it immediately burns to the pentoxide with a most brilliant flash of flame.

ACTION OF HALOGENS.

When phosphorous oxide is thrown into a vessel containing chlorine gas, it instantly takes fire and burns with a pale green flame. If chlorine is led over the oxide at the ordinary temperature, violent combustion also occurs; but if the vessel containing the oxide is cooled by ice, the reaction occurs in a more moderate manner. The product is a clear liquid which is found to be a mixture of phosphorous oxychloride, $POCl_3$, which may be distilled off, and metaphosphoryl chloride, PO_2Cl, which remains as a viscous residue after the distillation of the phosphorous oxychloride. The reaction occurs in complete accordance with the equation

$$P_4O_6 + 4Cl_2 = 2POCl_3 + 2PO_2Cl.$$

Bromine also acts with considerable violence upon the oxide, generally with incandescence. Analogous products are eventually obtained as in the case of chlorine; but if the experiment is so arranged that the vapors of the two substances only are allowed to react at the ordinary temperature, an intermediate reaction occurs with deposition of annuli of large and very perfect crystals of phosphorous pentabromide, PBr_5, phosphorous pentoxide being also formed at the surface of the phosphorous oxide.

Iodine only slowly reacts with the oxide, and best when the two substances are dissolved in carbon bisulphide and the solution heated in a sealed tube. On cooling, orange red crystals of P_2I_4 separate out.

ACTION OF SULPHUR—FORMATION OF A SULPHOXIDE OF PHOSPHORUS.

Sulphur reacts with the oxide in a most interesting manner, producing a beautifully crystalline addition compound of the empirical formula $P_4O_6S_3$. The reaction is best carried out in a sealed tube, about five grammes of the oxide and the corresponding quantity of sulphur being placed together in the tube, which has previously been filled with carbon dioxide or nitrogen. The tube is fixed upright, and its lower portion, containing the mixture, is heated in a glycerine bath. No reaction occurs, the two liquids remaining in separate layers until a temperature in the neighborhood of 160° is attained, when sudden and very violent combination takes place, the tube being usually shattered into fragments if more than 5 grammes of the oxide are employed. The sulphoxide produced is a pale yellow solid substance which melts at about 102°, and boils without decomposition at 295°. When heated *in vacuo* it sublimes largely in the form of tetragonal prisms of considerable size, quite colorless and transparent; a certain amount frequently condenses in a vitreous form which eventually devitrifies into feathery aggregates of the tetragonal prisms. Occasionally long needles, elongated tetragonal prisms, are formed. A very slight residue usually remains of sulphur, to which the yellowish color of the crude product is probably due. The sulphoxide is soluble in carbon bisulphide, and the solution deposits it again in tetragonal prisms on evaporation.

As phosphorous sulphoxide is undecomposed even at 400° C., it has been found possible to determine its vapor density by Victor Meyer's method in an atmosphere of nitrogen. The numbers obtained agree with the double formula $P_4O_6S_6$. Hence phosphorous sulphoxide is a direct sulphur addition product of phosphorous oxide.

It is deliquescent, and is decomposed by water with liberation of sulphureted hydrogen and formation of phosphoric acid.

OTHER REACTIONS OF PHOSPHOROUS OXIDE.

Ammonia gas, when led over melted phosphorous oxide, causes immediate ignition of the mass. When the oxide is dissolved in ether, however, the action is more manageable, and a new white solid compound is formed. This compound is the diamide of phosphorous acid, $P\begin{cases}NH_2\\NH_2\\OH\end{cases}$. It is an amorphous powder which dissolves instantly in water with production of flame. Dilute hydrochloric acid liberates pure non-spontaneously inflammable phosphureted hydrogen from it, owing to the decomposition, at the high temperature brought about by the reaction, of the phosphorous acid first produced.

Hydrochloric acid gas converts the oxide into phosphorous trichloride and phosphorous acid, the former being readily decanted from the latter at the close of the experiment.

$$P_4O_6 + 6HCl = 2PCl_3 + 2H_2PO_3.$$

Concentrated *sulphuric acid* deflagrates violently with phosphorous oxide with production of flame, formation of phosphoric acid, and liberation of sulphur dioxide.

Caustic alkalies, when tolerably concentrated, at once decompose the oxide with production of a flame of burning phosphureted hydrogen, red phosphorus being deposited, and a phosphate formed.

Sulphur chloride and *phosphorous pentachloride* respectively react with great energy with the oxide, the resulting liquid products being immediately raised to the boiling point. When the reactions are performed in vessels cooled by ice, the products may be collected and examined. Sulphur chloride yields a mixture of oxychloride and sulphochloride of phosphorus,

$$P_4O_6 + 6S_2Cl_2 = 2POCl_3 + 2PSCl_3 + 2SO_2 + 8S.$$

Phosphorous pentachloride produces a mixture of oxychloride and trichloride of phosphorus,

$$P_4O_6 + 6PCl_5 = 6POCl_3 + 4PCl_3.$$

Ethyl alcohol instantly sets fire to phosphorous oxide. The reaction may readily be moderated, however, by cooling the vessel by ice, and under these circumstances a new liquid, diethyl phosphorous acid $P\begin{cases}OC_2H_5\\OC_2H_5\\OH\end{cases}$, is produced. This liquid possesses a strong garlic-like odor, boils at 184°—185°, and has a specific gravity of 1·0749 at 15·5°.

An account of the properties of phosphorous oxide would not be complete without a reference to its physiological action. Most people are aware that persons engaged in lucifer match making occasionally suffer terribly from disease of the lower jaw, and it is found that this is due to the direct action of the fumes upon the bone. It would appear that this deplorable action is directly traceable to the vapor of the volatile phosphorous oxide now described, for this oxide is found to be largely formed when phosphorous oxidizes without igniting; and if any benefit in the way of increased precautions against such action should follow from the further knowledge now gained concerning this substance, none will rejoice more heartily than those who have attempted to place its chemical history upon a surer foundation.—*Nature*.

PECULIAR PERFORATION OF ZINC RODS.*

By CHARLES E. MUNROE.

THROUGH the courtesy of Asst. Eng. B. C. Bryan, of the U. S. torpedo boat Cushing, I received a short time since some fragments of zinc rods, which after exposure to the action of hot water in the wing cylinders of the Cushing's boilers had become perforated throughout their entire length with a central canal. These boilers are of the Thornycroft pattern, and each consists substantially of a horizontal cylinder or "separator," placed in the upper part of the furnace, and two horizontal cylinders placed below in the wings of the furnace, each of these "wing cylinders" being connected with the separator by a large number of steel "generating" tubes of small diameter, which are bent in such shapes and so placed as to form a continuous arch over the grate, and yet spring from the tops of the wing cylinders and enter the top of the separator. The wing cylinders are also connected with the separator by means of pipes, known as the "down-comers," which are of larger diameters and have a more direct lead than the generating tubes.

The effect of this arrangement is that, when the boiler is filled with water to its normal level of about half way up the separator and the fires are started, steam is rapidly generated in the generating tubes, from which it rises with the water to the separator, where, by means of baffle plates, separation is effected, the steam passing to the engines and the water descending by the down-comers to the wing cylinders, from which it again rises to the generating tubes, the circulation being thus maintained and its velocity being governed by the area and condition of the fire and the extent of the feed. As, owing to the disastrous effect of scale in these multitubular boilers, soft water only can be used in them, it is essential to condense the exhausted steam, but as the condenser is made of tinned brass tubes with a copper shell, the electro-chemical action between the metals tends to pit and corrode the steel boiler. Hence, to prevent this, and also the pitting, which, as I have elsewhere shown, may be caused by the action between masses of steel in different physical or chemical conditions, zinc, which is electropositive to the steel, is put in the boiler in such a way as to be in close metallic contact with it. This practice has long been in vogue for the protection of boilers, but more recently it has come into use for the preservation of the vessels themselves, Mr. Thornycroft, in his "instructions of March 15, 1889," for the care and preservation of the steel hulls of his torpedo boats, recommending that in order to protect them from pitting pieces of zinc be placed on the inside of the vessel at intervals of from 5 ft. to 6 ft. apart from stem to stern and as low down as possible, so that they may be immersed in any bilge water present, and so fastened as to be in close metallic contact with the frames of the vessel, the arrangement being made under the supervision of the naval chemist.

* Communicated to the *Journal of the American Chemical Society*.

Usually zinc for boilers is employed in the form of plates which are suspended in the boiler, and this is the form in which it is used in the separator of the Cushing's boiler, but it is introduced into the wing cylinders, which are 14 in. internal diameter by 8 ft. in length, in the form of cylindrical rods, 1¾ in. in diameter by 5 ft. in length, which are squared off for about 1 in. in length at each end, so as to fit into notches in a steel frame from which they are suspended by their ends in the center of the wing cylinder. These rods have evidently been cast vertically, and when an unused one is fractured the exposed surface of the interior shows a mass of feather-like fretted crystals radiating in pyramidal groups from the center, but forming a compact mass, except for an occasional, but non-continuous, small cavity at the center.

The exterior of the rod is of a dull blue color, and appears to have been "chilled" in casting. The rods from which the pieces were taken had been exposed in the boiler for about two months, but the steam was on during this time for but 608 hours, the pressure varying from 50 to 250 pounds, which is equivalent to temperatures of from 137° C. to 205° C. When taken from the boiler, these rods were found to have increased considerably in diameter; to have become oval in form; to be perforated throughout their entire length, with a hole at the center of somewhat irregular shape, and varying in diameter from 1/16 in. to ¼ in.; to be more or less corroded at intervals on the surface; to be bent down between the points of suspension; and to be so rotten as to easily break under their own weight. The extent of the increase in diameter is shown from the following measurements of five sections from used rods, the diameter of the unused rod being 1¾ in.

DIAMETERS.

	Maximum.	Minimum.
1st section	1⅞ in.	1⅝ in.
2d "	1⅞ in.	1⅝ in.
3d "	1⅞ in.	1⅝ in.
4th "	1⅞ in.	1⅝ in.
5th "	1⅞ in.	1⅝ in.

When split longitudinally these sections were found to be filled with radial fissures, and the bundles of feather-shaped crystals were coated superficially with oxide.

From consideration of the circumstances I am of the opinion that the formation of the tubular canals in the rods is due to the fact that, as cast, the radiating crystalline mass is held in place by the outer envelope of metal which is produced by the contact of the exterior portion of the molten mass with the cooler walls of the mould, and that when, through the erosion or corrosion of this envelope by the rapidly circulating heated water, the tension is removed, the crystals are free to move over one another; and that, when cooled from the high temperature to which they have attained, the bundles of crystals contract along the transverse axis of the rod away from the center, and since there is no longer a contracting continuous exterior envelope to bring them back to their original positions, the canals result. The oval form which the rods assume is due to the action of the force of gravitation at the time when the force of attraction of cohesion among the particles of the mass is least. And the action is aided by the fact that the higher limit of temperature which obtains in the boiler is approximately that at which cast zinc becomes quite easily disintegrated.

I am informed by Lieut. Cameron McR. Winslow, U.S.N., commanding the Cushing, to whose courtesy I am much indebted, that 250 lb. of zinc are used for a single charge in one boiler, and that when the boilers are first run this charge is so completely destroyed in seven days' steaming that sometimes only small fragments and sometimes no portion whatever of the zinc is found remaining in the boiler at the end of this time. I have had no opportunity of learning what becomes of this mass, as the Cushing was put out of commission when my attention was called to the matter.

A NEW ACID.

A NEW acid, chromosulphuric, possessing the composition $H_2Cr_2(SO_4)_4$, is described, says *Nature*, by M. Recoura in the current number of the *Comptes Rendus*. A short time ago the same chemist obtained a remarkable isomeric form of chromic sulphate, $Cr_2(SO_4)_3$, which exhibited neither the reactions of a sulphate nor of a salt of chromium. For instance, its solution yielded no precipitate of barium sulphate with barium chloride. This isomeric form of chromic sulphate is found to combine directly with one equivalent of sulphuric acid or of a metallic sulphate to produce the new acid, or a salt of it. Thus, when a solution of zinc sulphate is mixed with a solution of the isomeric sulphate of chromium in equivalent molecular proportion, zinc chromosulphate is formed, $ZnCr_2(SO_4)_4$.

The solution of this zinc salt so obtained gives none of the reactions of sulphuric acid, nor does it yield those of chromic acid, but it exhibits the usual reactions of zinc salts; hence it must be a zinc salt of a specific acid, chromosulphuric. When the solutions of the new acid and its salts are allowed to stand, they gradually decompose, and barium chloride commences to precipitate barium sulphate; hence they appear not to be very stable, but to decompose slowly into a mixture of ordinary chromic sulphate and sulphuric acid or the metallic sulphate. Boiling brings about the decomposition at once. The acid itself has been obtained in the solid state, combined with eleven molecules of water; it is a green powder, which is very hygroscopic, and rapidly deliquesces in moist air, but is quite permanent in a dry atmosphere. Its solution possesses a brilliant green color when freshly prepared, but, upon standing, changes to blue, and, after a few days, passes completely into a violet-colored solution of ordinary chromic sulphate mixed with free sulphuric acid. The potassium salt has also been obtained in the solid state, combined with four molecules of water, as a green powder whose dilute solution yields no precipitate with barium chloride, but at once gives the usual potassium precipitates with platinic chloride and picric acid.

This salt also appears to be formed when chrome alum is dehydrated first for some time at 90°, and finally at 110°. The sodium and ammonium salts have likewise been obtained, and are found to resemble the potassium salt closely in their nature and properties.

THE ROCHE DAIRY.

DAIRIES that daily treat from 1,250 to 2,500 gallons of milk are of comparatively recent installation, and date back to no more than fifteen years. Up till then, the difficulties of natural creaming, its irregularity and the great space that it necessitated, rendered the treatment of the milk on a large scale impossible. The centrifugal creamer has revolutionized this industry.

It permits of separating the cream almost instantaneously, in order to be afterward put in the condition necessary for the manufacture of butter of the quality desired. The creamed milk is obtained absolutely fresh and may be used as a cheap aliment or for the manufacture of cheese.

The milk consists, on an average, of the following elements:

Fatty matters	41·45
Casein, albumen	31·40
Sugar of milk	50·50
Salts	4·60
Water	872·05

We propose to follow the successive operations that permit of isolating these elements for the production of butter and cheese. We shall take as an example the Roche dairy, situated at the foot of the last chains of the French Jura, at the beginning of the low valley of the Loue, called the Val d'Amour.

Pastures are abundant here, the grass is fine and fragrant, the water is cool, and all things concur to permit of finding large quantities of milk of superior quality within a small radius.

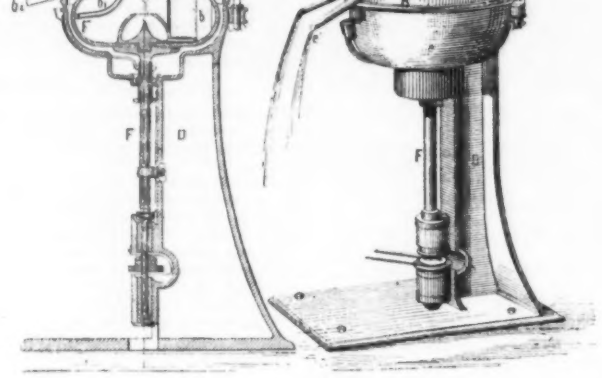
At sunrise and sunset the cows are milked everywhere in the pastures of the cultivator, who immediately carries the milk all afoam to the teamster. In this way the carriage is always effected in the coolest part of the day. At the dairy, the milk is weighed and verified, and all suspected milk is set aside, and then returned to the sender, and the proper penalty imposed.

A large vat receives all the milk and distributes it to a battery of three creamers, which deliver 375 gallons per hour at a velocity of 7,000 revolutions per minute. Under the action of centrifugal force, the skim milk is thrown to the periphery, and the butter globules, which are lighter, collect in the interior. The creamed milk is sent to the cheese room and the cream to the butter dairy.

Manufacture of Butter.—The butter dairy is a vast room provided with large windows, through which enter large quantities of air and light. The building stands with its back to the mountain and is protected to the south by fir trees. A very uniform temperature (12°) is maintained in it in winter by steam pipes and in summer by cool water, which runs along the walls and collects in a gutter in the center of the room. So it is necessary to put on wooden shoes in order to enter. Cigars must be left at the door, since cream and butter very quickly absorb all odors.

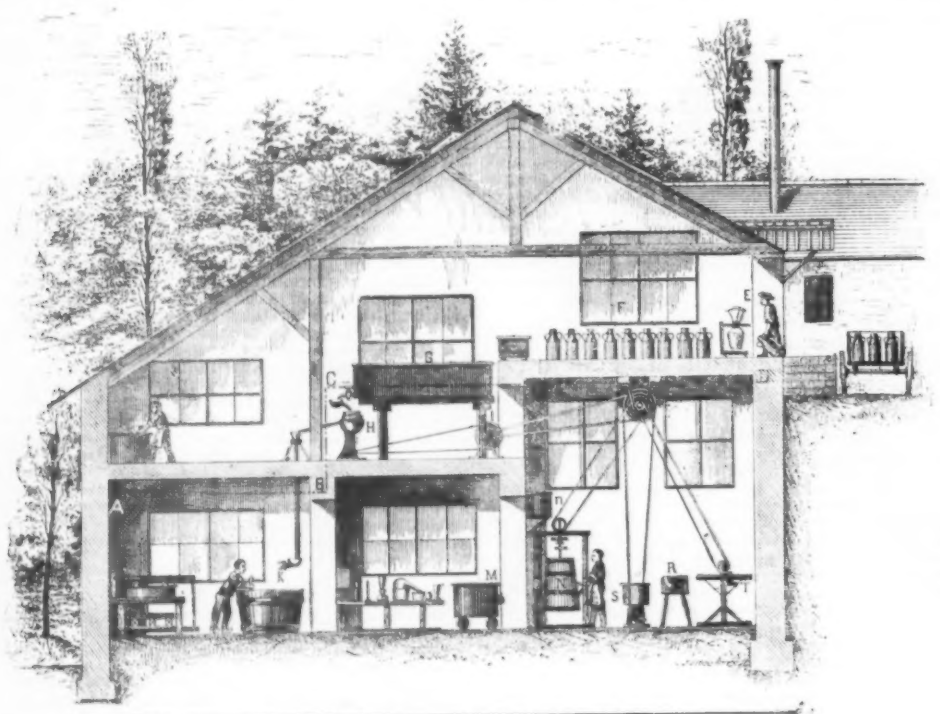
It is necessary to use extreme care in the treatment of the cream. If the temperature is too low (8°), the fermentation does not proceed well, and sweet butter without much perfume is obtained, but which may be preserved for a long time. In Denmark this method of manufacture is much employed for butter designed for exportation. If the temperature of the cream is too high (13°), it becomes acid, the butter takes on an acrid after taste which burns the throat, and it cannot be preserved so well. It is therefore necessary to let the cream rest in vats with double sides, between which circulates either tepid water or iced water at will.

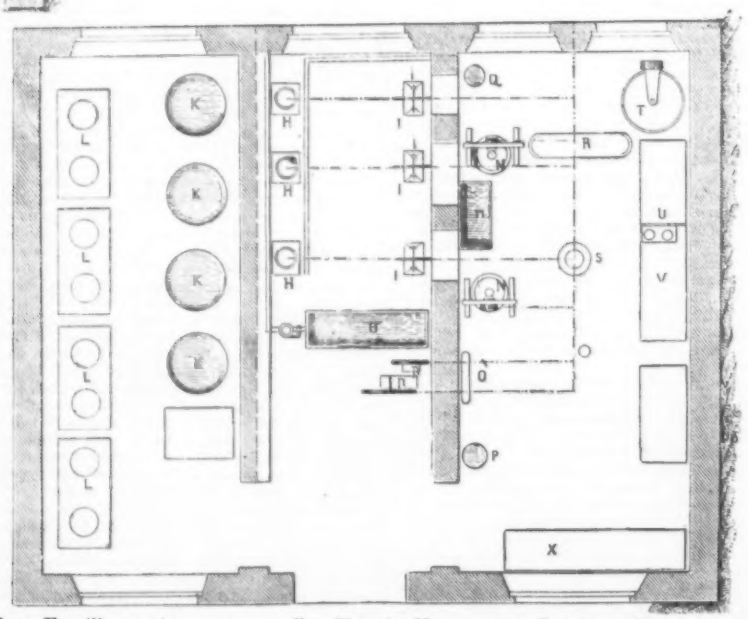
The cream is afterward put into churns moved mechanically, which convert it into butter in twenty-five minutes. Then comes a careful washing with plenty of water (Norman process). In the Danish process, the butter is not washed. The buttermilk is removed by treatment in the milk separator. The kneading ap-



F F, movable basin; D, stationary frame; L, rich milk; *d*, cream making its exit at *e* and then at *e'*; *b*, creamed milk making its exit at *b* and then at b_2; B C, fixed covers.

FIG. 1.—LAVAL'S CENTRIFUGAL CREAMER.





E, milk scales; F, milk can storage room; G, milk vat; H, creamers; I, intermediate movement; K, cheese boiler; L, presses; M, laboratory; *n*, cream vat; N, churns; O, refrigeratory; P, cold water; Q, warm water; R, butter trough; S, milk separator; T, butter worker; U, trough in which the butter is hardened; V, 33 lb. balls; *p p*, pumps.

FIG. 2.—SECTION AND PLAN OF THE ROCHE DAIRY.

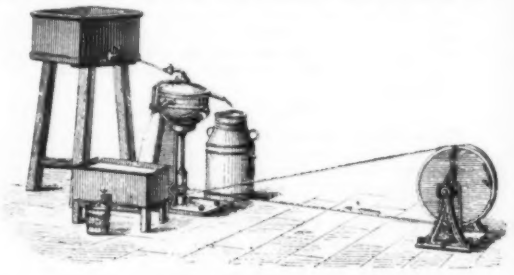


FIG. 3.—ARRANGEMENT OF THE CENTRIFUGAL CREAMER.

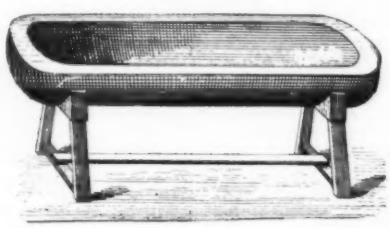


FIG. 4.—TROUGH.

FIG. 5.—DANISH CHURN.

paratus gives the butter the desired consistency and removes the last traces of water.

In all these operations, the workman has merely to turn cocks and start or tilt machines, without ever touching the butter. Owing to the minutiæ of the manufacture, there is obtained an irreproachable product capable of being preserved for a long time, and which may be shipped in a fresh state to Algeria, Turkey and Egypt.

For shipment, the butter is put up in balls of 33 pounds, designed for sale in the markets, or else in rolls of from 1 pound to 5½ pounds for delivery to private parties.

In the latter case the roll is carefully wrapped in parchment paper and placed in an odorless whitewood box for shipments in France, or in a tin box for Algeria and Tunis. The number of postal packages sent daily necessitates a special department for packing and labeling. Each customer has his special hook to which are consigned his tastes, his recommendations, the packing that he prefers, etc.

Manufacture of Gruyere Cheese.—The creamed milk is put into double-bottomed boilers of 125 gallons capacity, heated by steam. It is then renneted, that is to say, it is mixed with a liquid obtained through the maceration of the inner membrane of the fourth stomach of the calf, which effects the coagulation of it in twenty minutes. The curd is divided into small grains which are heated to about 40°, and continuously stirred in order to cook them and separate them from the whey. The grains of casein, collected together in a cloth, are put in a press, which agglomerates them. The pieces of cheese weighing from 50 to 60 pounds are placed in the cellar, where they are salted, for about six months. Under the influence of humidity and the temperature, which should vary between 12° and 16°, according to the age of the cheese, a very slow fermentation develops in them.

The residuum of the last operation is the whey, a greenish liquid, slightly purgative, containing sugar of milk and an albuminoid and caseous substance, which is coagulated by rennet only at a temperature of about 90°, and which, in the mountains, serves for the manufacture of *ceret*—one of the poorest of cheeses.

A small Audemar pump sucks this laxative liquid from the boilers and forces it through a 2,500 foot pipe line to the swinery, a vast hall perfectly ventilated, where it is used for the feeding of 250 hogs, which greedily eat it and become fat upon it, with the addition of a little oil cake and meal.

A Decauville carrier running everywhere facilitates the work to such a point that a single workman can very easily take care of all this population and wash out all the pens every day.

The last residua, washing water, dung and liquid manure, serve for soiling and irrigating the pasturages. —*Le Genie Civil.*

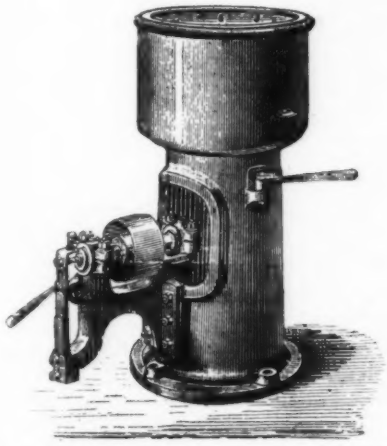


FIG. 6.—CENTRIFUGAL MILK SEPARATOR.

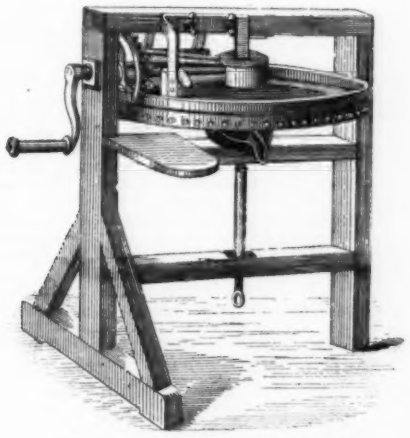


FIG. 7.—BUTTER WORKER.

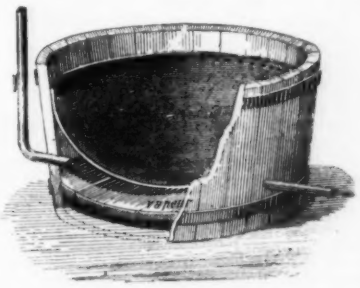


FIG. 8.—CHEESE VAT.

PRACTICAL FORESTRY.

By JOHN D. LYMAN, Exeter, N. H.

YOUNG timber trees should be thinned when they come up very thickly, in order for the owners to get the greatest profit from their trees, and also from sprout-covered land.

I send you the following statement of one of my experiments in growing white pine (*Pinus strobus*) upon an acre of poor land in New Durham, N. H., where pine wood and small trees for "kits," pails and the like are practically of little or no market value. My statements also contain, as you will note, various other matters of practical experience concerning forestry.

In the year 1870 I purchased the abandoned Pike Farm. Some two or three years afterward I noticed about an acre of little pines growing very thickly upon the land. In their condition at that time they had no market value. Mr. I. P. Berry, the treasurer of Strafford County, who lives near by, and who has thinned these trees for me, said, a few years ago, that I could not have sold that acre of land, with the little pines upon it when he commenced to thin them, for $3. The process of thinning out was commenced about 18 years ago, and has been continued at various times since, but the growth has never been sufficiently thinned, and even now numbers 178 trees. I think there should not be over 100 trees at this stage of growth.

For the purpose of thinning I lately cut one of the smallest, most crowded, and oldest trees on this acre. This tree has once lost its main top, which, of course, checked its growth for several years. Again, during several years it has been too much crowded; in fact, so much so that during the past ten years its growth has been very slow. Yet this tree was 77½ ft. in height, measured 13 in. across its stump, and 19 in. in circumference 57 ft. from the ground. I measured the circumference of the trees four feet from the ground, standing nearest a straight line drawn through the center of the lot, and found the average to be a little over 40 in. One tree standing on the edge, and not included in those which averaged 40 in. in circumference, girded 74 in. four feet from the ground. This one, of course, is "limby" on the side toward the cleared land.

As these pines came up very thickly they had no large, low limbs. Their small limbs died up for quite a distance from the ground. Several years ago I removed these little dead limbs, leaving none within 12 ft. of the ground. Not being able to secure a suitable saw in Boston, I had one made from a wood saw, and at an outlay of about three cents a tree I have lately had these dead limbs taken off, say 18 or 20 ft. from the ground. My object in taking off these dead limbs is not to promote growth, but to prevent having loose black knots in the boards when sawed. I presume it is generally known that while the pine limb is alive the knot is of a reddish hue and secured fast to the wood, but after the limb dies the annual growth of the trunk pushes out over the dead limb, and this part of the knot is black, and often so loose as to fall out and leave a hole in the board when sawed from the log. The difference in value between clear pine boards and those abounding in knots, and especially in black, loose knots, and knot holes, is well understood by those who buy and sell lumber. In my experiments I am attempting to grow good lumber, instead of knotty, cheap lumber.

The greatest number of rings (which generally correctly indicates the age of the tree) which I have ever found in any pine in the clump of which I am writing was 45. This number of rings I found in the tree lately cut. As its height was 77½ ft., the annual gain in height was 20⅘ in., presuming the tree to be 45 years of age.

The fencing, shingle stuff and small timber taken from this clump in the process of thinning have very liberally paid all expenses connected therewith. Had this acre been left entirely to nature and nature's methods of growth, there would have been at this time some 70 cords of wood upon it, which for fuel would have paid little or nothing over operating expenses at present market values. The border trees, and, in fact, a few others, under nature's methods would have made small timber or box boards, of but little value.

I have never seen the groves of trees set out by the wealthy Massachusetts amateurs, Mr. Fay, of Boston, and others, nor have I had the pleasure of their acquaintance, but I think they would have found their investments more profitable had they properly thinned their groves from time to time. Thinning requires judgment and experience. The scorching of the trees by the sudden admission of too much sunshine upon the tender bark is to be avoided. The danger of wind is to be guarded against. Then, if the trees are too far apart they grow too "limby," and if left too thick they grow too slim and too slowly.

In my reading I have learned of no other family which set so many acres to forest trees as did the Dukes of Athol. They were at last sadly disappointed by their forests becoming diseased and ceasing to grow. I do not know sufficient of the conditions for an accurate guess of the cause of the difficulty in these forests, yet I think the probable cause was in not having their plantations properly thinned.

One of the first points to be learned in order to grow a crop, whether of timber, corn, or any other, is the number of plants to the acre which will produce the best results. Thus too many corn plants give nubbins or no ears at all; too many potato stalks give small potatoes, too many tree plants give poles instead of timber. Years ago, my idea was to have pines for timber trees very thickly set when young, so as to prevent large lower limbs. This theory proves to be a correct one. I then thought to thin out many times until the trees were about 45 years of age, and then to leave 100 to the acre until they were about 60 years of age, when I expected the trees to average each the equivalent of 500 feet of inch boards, or 50,000 feet of inch lumber to the acre. I then proposed cutting the whole or thinning again. After years of subsequent experimenting and observation I think I was about right at that time, though perhaps 80 pine trees at 45 years of age to the acre would prove more profitable in the end than 100 trees to the acre.

To my surprise, however, B. E. Fernow, chief of the Forestry Division under the United States Government, issued his official bulletin No. 5 on forestry, in which he states that 270 is in general the right number of timber trees to stand to the acre 100 years for timber. If this high official is right in theory, I am far from right in practice. Pines take less room than oaks and other branching trees, yet I have studied nature and her ways without avail if theorists rightly conclude that 270 white pine trees is the proper number to be grown to the acre for timber until a hundred years of age.

Since receiving Mr. Fernow's statement, which seems a remarkable one to me, I have with measuring line traversed our forests, and carefully studied their growths, and I have consulted many owners of forests and many lumber operators, who have got hundreds of acres of pine trees, but I find not one of them confirming the theory of growing so many trees to the acre as is recommended by the chief of the Forestry Division.

The white pine (*Pinus strobus*) a hundred years in growing certainly should make 1,000 feet of inch boards at the mill and thus we should have 270,000 feet of inch lumber to the acre, or an average growth of 2,700 feet per acre each year of the hundred. This is far beyond any growth to be found in my section. In my experience while lumbering I never cut 100,000 feet board measure upon any one acre. By reading I learn of the large amount of timber per acre in the far West. Personally I have only seen the forests between the St. Lawrence River and the Savannah River of Georgia, and from Maine to Kansas.

For years the Division of Forestry has been warning the people of the United States of the near approach of a great scarcity of wood and timber in this country; in fact, the figures of the then chief of this division, at a meeting in Boston in 1885, show that our forests would all be gone by the year 1893 or 1894, and yet the official statement is that we have 490,000,000 acres of forests, and that we can grow on the average 270 timber trees to the acre. Allowing a century-old timber tree to make 1,000 ft. of boards, and taking this official statement that on an average 270 timber trees can be grown to the acre, then the yearly growth at this rate would be 1,323,000,000,000, or more than 100,000 ft. board measure for each family in our country. Alaska, with its vast forests, is left entirely out of this calculation.

According to the census of 1880, we were cutting in the United States, 18,091,356,090 ft. board measure of lumber yearly, or less than $\frac{1}{73}$ part as much as the yearly growth would be upon the above basis. In cold New Hampshire we can grow about 1,000 ft. of inch box boards upon an acre in a year, or from 600 to 700 ft. of the best white pine timber upon an acre in a year, but to do this the conditions must be favorable. Judging from what observation and experiments teach me concerning the forests, it would be difficult to find two parties further from the truth than the one who urges the necessity of admitting Canadian lumber free from duty, in order to save our forests, and the other, the Division of Forestry, in such statements as I have quoted above.

Set in regular squares, 270 trees to the acre would stand a little over 12⅛ ft. apart from center to center of trees. After much traveling and searching through the forests, I can find no two pines of considerable size and thriftiness standing thus near to each other, with any considerable number of live limbs on the sides facing each other. Nor can I find such a pine surrounded by trees equally high, and only 13 ft. distant. I have not found one single tree answering these conditions. Surely Dame Nature, here in New Hampshire, declares Chief Fernow in error.

One of my last object lessons in forestry from nature was in the grand old woods upon the agricultural college farm in Durham, N. H. Here nature, upon good land, at a very low altitude, with all the conditions favorable, had a fine chance to show what she could do at forestry, when undisturbed for a period of 140 to 150 years. Professor Pettee, of the college, selected at my request what he considered as good an acre of pine timber as the forest contained. Upon that measured acre we found 156 live trees and 34 dead ones, including those which had already died and fallen. Their circumference four feet from the ground varied from 22 inches to 98 inches. There were a few little hemlocks, and but few in fact so small that we did not count them. Two of these 190 were birches, two white oaks, one maple, 90 hemlocks, while the balance were white pines. The average circumference of the 190 trees four feet from the ground is 54 inches and a fraction. That clump of New Durham pines belonging to me, described at the commencement of this article, has more than half as much timber to the acre as has that Durham College acre, and will, barring accidents, by the time that the trees are one-half the age of the Durham trees, have not only more timber to the acre, but that of better quality.

This shows the advantage of aiding nature in the production of timber, the same as in the production of other crops, and proves the profits of practical forestry. Why did the 34 trees on the Durham acre die? With very few exceptions, I have no doubt that they were shaded to death by the other trees, although there were only 190 trees, instead of 270, which Forestry Chief Fernow says is the proper number to grow upon an acre. Again, a hemlock tree will grow in the shade where a white pine tree will die, and hence I presume by mixing hemlocks and white pines, as is the case in Durham, more trees can be grown to the acre than there could be of white pines alone.

I must admit that what little I know of forestry has been obtained from something more than half a century of observation of the forests themselves, and with but little benefit from the books published on this subject. In boyhood I had followed Pope's precept without knowing it:

> First follow Nature, and your judgment frame
> By her just standard, which remains the same.

Since the remarkable line of instruction from Mr. Fernow, chief of the Forestry Division, however, I have been looking up to some extent the book authorities on timber growing, and have found that my humble conclusions, drawn from nature, agree with these high authorities far better than they agree with Forest Chief Fernow. Salmon says: "Keep the distance of the trees from each other equal to one-fifth their height." (Loudon's Encyclopædia of Agriculture, page 652.) This gives 170 to the acre when the trees are 80 ft. in height. I have one acre of pines 80 ft. in height with 170 trees upon it, and I think they are too thick. At their average rate of growth they will be 100 ft. in height in about 12 years, and then should have, by Salmon's rule, only 108 to the acre, yet my trees at that time will be less than 60 years old. By the time they are 100 years old there should be, by this rule, not upward of 69 to the acre at most. My own judgment is that they should average considerably over 1,000 ft. to the tree at that time, and, I think, would be too much crowded.

Hon. Martin Conrad stated in the Ohio State Forestry annual report that it would be proper to have 110 trees to the acre at 80 years of age, when he expects them to average 500 ft., board measure, to the tree.

E. B. Hough, in "Elements of Forestry," page 332, says that at Balmoral, Scotland, old Scotch pines have from 90 to 100 trees to the acre. It must be remembered that Scotch acres measure 6,150 square yards, as against 4,840 square yards to our acre.

In Brown's Forester, page 97, we find: "Forest pines for shelter and timber ought to be a little over one-third their height apart, which is found to be the most favorable distance for timber trees." The same author says: "Timber pines in Gascony have about 200 trees to the hectare," or nearly 2½ of our acres. The same author, page 99, says: "Hardwood trees, principally for the sake of value in timber, and of giving shelter at the same time, should have the distance between them equal to about one-half their height."

Marsh speaks of 50 large maples to the acre sometimes (see "Forests and Moisture"), as though that were a remarkable number.

Again, in Brown's Forester, page 99, we find the following: "A little more than one-third their height is the proper distance between pines and firs." This gives less than 48 trees to the acre when 90 feet in height. E. B. Hough truly says that evergreen and coniferous trees can be grown thicker than deciduous trees.

James Brown says: "Two hundred oak trees, grown 100 years on one (Scotch) acre, sold for $1,800, counting $5 to the pound, but 104 oaks, grown 90 years upon an acre, sold for $4,340." See page 366. This was in 1820, when oak and its bark were very high in price.

Loudon, Book 11, page 653: "It may, however, be said in general that if trees are allowed a certain distance of from 25 to 30 ft. between them, according to the manner of their growth, they will have room to become large timber." This gives from 69 down to 48 trees to the acre.

Poultney says 40 ft. apart, or only about 27 to the acre, is the distance necessary to the unassisted growth of large oaks. He adds, however, that they may be trained so as to grow 25 ft. apart.

With present prices of timber and labor we shall not be likely to perform the very difficult task of shortening in or pollarding the tops of oaks, so as to grow more to the acre. Owning more than 300 acres of young trees, and having no theories to defend, but simply searching for the truth, I should be glad to find the theories advanced by the chief of the Division of Forestry to be correct. If he is correct my property is the more valuable. My observation, however, proves his statements contradicted in the first place by nature, and in the second place by forest owners, lumbermen, professional foresters, and acknowledged authorities among the writers upon forestry.—*Amer. Cultivator.*

SANDALWOOD.

THESE notes are partly derived from a report rendered by Mr. C. E. M. Russell, Superintendent of Forests in Mysore:

Sandalwood is the most important source of forest revenue in Mysore. It is a monopoly of the Mysore government, and, except by government agency, no sandal tree can be uprooted or cut down, even upon land which is private property. The only exceptions are the Jahgidar of Yelandur and the Guru of the Sringeri Matt, who are permitted to cut and dispose of the sandalwood of their own Jahgirs. The tree is plentiful in the Mysore country, and occurs also, but in far less quantities, in those portions of the Madras territory which border upon Mysore. For practical purposes, however, Mysore may be said to almost hold the monopoly of the sandal supply. It is a somewhat delicate tree, is killed outright by fire, is very impatient of injuries to the roots and bark, and requires shade and protection while young. The value of the wood is dependent upon a volatile oil which is contained in the heartwood only, and in order that this oil may be developed in the highest possible degree it is necessary that the growth of the tree should be slow. Consequently sandalwood grown in arid situations, on poor, stony soil, is, though small, of far more value than is that produced by large, well grown trees growing in moist situations and in richer soil. The maturation period of the sandal tree is variously stated at from forty to sixty years. Sandalwood is not eaten by white ants, and its oil preserves it from decay in a remarkable degree, of which the present collection of old sandal roots left in the ground for many years past is a conclusive proof. In former times it was the custom not to uproot but to fell sandal trees, whereas for many years past the trees have been uprooted, and the roots, which contain a higher percentage of oil than the wood, are in great demand and command high prices.

Even in periods of depression of the sandal market a fair demand for roots has always been noticeable. The method of preparation is as follows:

The trees, having been uprooted, are roughly deprived of bark and some of the sapwood on the spot, and are then carted into the nearest of the sandal Kothis, of which nine exist in the Mysore province.

On arrival at the Kothis the trunks are sawed off above the roots, cut into lengths, all the whitewood removed, the billets adzed and subsequently planed and smoothed, the roots adzed and free of all adhering bark, mud and whitewood, and the various products—billets, chips, small pieces, hollow wood, saw powder, etc.—collected and classified according to the classes represented by the specimens forming the sandal trophy. About the months of November or December auction sales of the various classes are held in all the Kothis of the province, and are so arranged, as regards the dates fixed for holding the same, that the purchasers may, if they choose, attend the sales in Shimoga, Kadur and Hassan, and yet be in time for those in Mysore and in Bangalore.

Chief Markets for Sandalwood.—It will be matter for surprise that so valuable a wood, and one of which a single province may almost be said to hold the monopoly, should be so little known outside of India.

The fact is that the trade in Mysore sandalwood has hitherto been confined to a ring, consisting chiefly of Mohammedan Seits, who, either as principals or as agents of Bombay firms, attend the local sales and send the sandalwood purchased by them to Bombay. The transit to Bombay from the coast is by sea in native crafts. The railways might, perhaps, secure this traffic if they offered special rates.

The carts that convey the sandalwood to the coast are hired at low rates, as they are certain of return loads of salt and other merchandise to Mysore. Until recently, nearly all the sandalwood sold in the auctions held by the Mysore government went to Bombay, but a demand having lately arisen for sandal oil for medicinal purposes, some direct shipments of wood for extraction of oil to France and Germany, and probably also to America, have been made.

A small quantity of sandalwood is produced in the Madras Presidency and in the Bombay districts of North Canara and Dharwar.

Sandalwood Oil.—The Mysore government has long had establishments for extracting the oil, which is sold at the annual auction along with the wood, and chiefly bought up for exportation to China and Arabia. It is procured from the wood by distillation, the roots yielding the largest quantity and finest quality of oil. The body of the still is a large globular clay pot with a circular mouth, and is about 2½ feet deep by 6½ feet in circumference at the bilge. No cap is used, but the mouth of the still, when charged, is closed with a clay lid, having a small hole in its center, through which a bent copper tube about 5½ feet long is passed, for the escape of the vapor. The lower end of the tube is conveyed inside a copper receiver, placed in a large porous vessel containing cold water. When preparing the sandal for distillation, the white or sap wood is rejected, and the heartwood is cut into small chips, and distillation is carried on slowly for ten days and nights, by which time the whole of the oil is extracted. As the water from time to time gets low in the still, fresh supplies are added from the heated contents of the refrigerator. The quantity of oil yielded by wood of a good quality is at the rate of 10 ounces per maund, or 2 to 5 per cent. It is transparent and of a pale yellow color, and has a resinous taste and sweet, peculiar smell, which is best appreciated by rubbing a few drops of the oil on the warm hand. Its specific gravity is about 0·980 (Bidie). The average price in India is about Rs. 8 per pound.

SHOOTING STARS.

THE shooting stars are small bodies, weighing at most a few pounds, and consisting mainly of iron and carbon. They traverse space in swarms, and also revolve around the sun in long elliptical courses like the comets. When these little bodies enter the earth's orbit, they are deflected toward the earth, and great numbers are seen in a single night. Their brightness is due to the heat engendered by the energy of their motion. Their speed is enormous, viz., 42½ kilometers a second, while the speed of the earth on its orbit is only 25 kilometers a second forward. Consequently when a shower of them approaches the earth in the direction opposite to its course the initial speed is 72 kilometers a second; when they follow on its course, they gain 16½ kilometers a second on it, their mean rate of approach being 30 to 40 kilometers a second. The friction engenders a temperature of 3,000 degs. Celsius, subject to which they burst into flame. If under these conditions their substance is not vaporized, they pass through and beyond the upper strata of our atmosphere, and pursue their proper course around the sun; but as a rule they are vaporized, in which case the vapor mingles with the atmosphere, to fall later as meteoric dust. In this manner we come in contact annually with 146 milliards of shooting stars, which add considerably to the earth's substance.

Every year shooting stars present the most interesting spectacle on the night of August 10, and frequently also on the two following nights. If the night is clear and the observation is not disturbed by the moonlight, one may count hundreds and even thousands of falling stars during these three nights, all coming from apparently the same quarter of the heavens, the constellation of Perseus. The fact that the earth takes three days to pass through the shower of shooting stars affords a measure of the enormous space they occupy, the more so that they cross our orbit at right angles to the earth's course. Their orbit is a long one, and corresponds with that of the great comet of 1862, which reaches a distance of 7,104,000,000 kilometers from the sun, approaching it at intervals of 121 years. This immense orbit appears to be full of shooting stars. Another date equally interesting for the observation of shooting stars is November 14. On this date they are even more numerous than on August 10. At intervals of thirty-three years they fall on this date as thick as snowflakes. Two hundred and forty thousand are estimated to have fallen on November 14, 1833; the phenomenon repeated itself in 1866, and we look forward to its recurrence in 1899. The November shooting stars appear to come out of the constellation Leo. The course of this group corresponds to that of the comet of 1866, near the orbit of Uranus, at a distance of 2,840 kilometers from the sun, which it approaches every thirty-three years. In the year 126 A. D. this comet under the influence of the attraction of Uranus was deflected from its original course, and made a member of the solar system.

The two dates above mentioned are not, however, the only ones on which shooting stars in considerable numbers may be observed. Among others, November 27 may be mentioned, for on this day in 1872, and again in 1885, at least a hundred thousand shooting stars were observed. In Rome, where I was on the latter date, the phenomenon excited great interest, and even the Pope was evidently not wholly unmoved; for some days later, when I had the honor of being received by his Holiness, his first words were: "Did you see the golden shower of Danae?" The shower of fixed stars of 1872 was entirely unexpected by the astronomers.

They had been much disturbed at the loss of Bela's comet, which after its discovery steadily made its appearance at intervals of six and a half years until 1846, in accordance with its computed course. On this occasion, while pursuing its course on the night of January 13, it split into two pieces, diverging from each other as they pursued their several courses. Both comets were visible on their return in 1852, but they were pale and faded and more than two million kilometers apart. It was the last sight; from that date the Bela comet has never been seen again. It is vanished, annihilated, burst up into shooting stars. Were this not so, it must have bisected the earth's orbit on November 29, 1872, and actually have come into contact with it. In its stead there appeared unexpectedly the above mentioned shower of stars, and the conclusion was that these small bodies were the remains of the Bela comet, a conclusion unquestionably confirmed by the observations of November 27, 1885.

This then is one of the latest conclusions of science: Shooting stars are the fragments of shivered comets. Comets, in fact, are comparatively short-lived bodies, few of them persisting beyond a few thousand years, and the smaller ones for a much less period only, while the duration of a planet like our earth extends to millions of years. The great comets which frightened our ancestors would doubtless be found to have lost much of their brilliancy if we could see and identify them; for during their course around the sun they continually throw off vapor and fragments, and are thus constantly subject to diminution.—*Camille Flammarion, in the Deutsche Revue.*

THE WENDS.

MODERN history is, in its rapid march onward, making sad havoc of old races. New nations are rising up, but only like new banks and headlands on our coast, by the accumulation of drifted shingle, which the very same tide is washing away from wasted older rock. A generation or two hence, in the making of a new German people, the last remnant will have finally disappeared of an interesting race, which historians and archæologists alike will be loth to miss. There are probably very few Englishmen who have any clear idea as to who the Wends or Sorbs are. They once overran all Germany, and severe indeed was the century-long struggle for possession between Christian German and heathen Wend. They were a powerful people in days gone by; in the days when Wendish warriors, like King Niklot, were feared in battle, their ships went forth across the sea, side by side with those of the Vikings, planting colonies on the Danish Isles, in Holland, in Spain, aye, and it is maintained even in England. The entire North German population from the Elbe eastward is, in descent, far more Wendish than German.

There are now but a poor 150,000 or 160,000 left of this once numerous people; Saxon oppression has obliterated or absorbed them. No man of any culture dared own himself a Wend. The race was doomed to be hewers of wood and drawers of water, toiling cultivators of the soil; their very name (Sorbs) standing for serfs, just as in the south "Slav" became the distinctive term for slave.

To the eye of the archæologist all this hardship has secured one compensating advantage. It has left the Wends—in dress, in customs, in habits of mind, in songs and traditions—most interestingly primitive. Everything specifically Wendish bears the unmistakable stamp of national childhood, early thought, old-world life. There has been no development within the race, as among other Slavs. There have been modern overlayings, no doubt; but they are all foreign additions. The Wendish kernel has remained untouched, displaying with remarkable distinctness that peculiarly characteristic feature which runs through all the Slav kindred, at once uniting and separating various tribes, combining a curious unity of substructure with a striking variety of surface.

In outward appearance, the Wends are throughout a powerful, muscular, and healthy race, whose men are coveted for the conscription. The first Napoleon's famous "Bouchers Saxons"—the Saxon Dragoons—were nearly all Wends. And in the present day it is the Wends who contribute the lion's share of recruits to the Saxon household regiments. Their women are prized throughout Germany as nurses. They are all well built, well shaped, rich in muscle, and nimble in motion, like the Lacedæmonian women of old. Next to stature, the most distinctive external feature of the race is their national dress, which, as in most similar cases, survives longest, and in its most characteristic form, among the women. As between different districts it varies very markedly, but throughout it has some common features. Short, bright-colored skirts, with the hips preternaturally enlarged by artificial padding, and an unconscionable amount of starch put into the petticoats on Sundays; close-fitting bodices, under which, in some districts, by an atrocious perversion of taste, are placed bits of stout cardboard, designed to compress a strongly developed bust to hideous flatness; small, tight-fitting caps, into which is gathered all the hair, and which are often concealed under some bright-colored outer headgear, with an abundance of ribbons dependent, and a goodly allowance of scrupulously clean collar, frill, and neckerchiefs, at any rate on Sundays; and, on festive occasions, stockings of the same irreproachable whiteness. These are, briefly put, the main characteristics of the women's dress.

The men delight in big buttons, bright waistcoats, and high boots, long coats which pass on from father to son through generations, and either preternatural stout hats of prehistoric mould or else large blue caps with monster shades. Their peculiar customs are simply legion, and so are their traditions and superstitions. Their fairs are a thing to see. Old-fashioned as the

Wends are, ordinary shopping has no attraction for them. But the merry fair, with its life and society, its exchange of gossip, its display of finery, its haggling and bargaining, its music, and its dancing, is irresistibly alluring. At the great fair in Vetzschau, in olden days, you might see as many as a thousand Wendish girls, all dressed in their best, formally, but merrily, going through their Wendish dances in the market place.

To see the Wends ethnographically at their best you should seek them in their forest homes all through that vast stretch of more or less pine-clad plain extending northward from the last distant spurs of the Riesengebirge to the utmost limits of their territory in the March of Brandenburg, or else in the beautiful Spreewald some hundred miles or so south of Berlin. This is the ancient headquarters of the Wendish nation, still peopled by a peculiar tribe, with peculiar, very quaint dress and conditions and customs all their own, settled round the venerated site of their old king's castle. It is all a land of mystic romance, sylvan silence, old world usages, such as well become the "Sacred Forest" of the ancient Suevi.—*Henry W. Wolff, in Westminster Review, London.*

[Continued from SUPPLEMENT, No. 858, page 13709.]

ON PEROXIDE OF HYDROGEN: A PHYSICAL-MEDICAL RESEARCH.*

By BENJAMIN WARD RICHARDSON, M.D, F.R.S.

PART II.—PHYSIOLOGICAL AND THERAPEUTICAL.

AT the close of the last chapter (*Asclepiad*, No. 29, p. 13) the action of purulent matter on the solution of peroxide of hydrogen was described. It was shown that the presence of purulent matter leads to a rapid evolution of the oxygen, and that during evolution the pus cell is destroyed. To the facts there stated, some further facts of practical importance, therapeutically, should be added.

The Peroxide and Blood.

Before I enter into any new details, I would submit a brief exposition of an analogy which has occurred to me between the oxidation of water manifested in the peroxide and the oxidation of blood. It seemed to me from the first that the additional oxygen in the peroxide is held in the same kind of loose combination with the water as the oxygen of the blood is held in the blood stream. The water of the blood does not give up its own oxygen, but it conveys to the tissues readily enough that which lies outside it in the corpuscles, as they come into contact with the tissues, just as the supercharged water of the peroxide solution gives up its oxygen when it is brought into contact with certain catalytic substances. Under this impression I conceived an idea of establishing a synthesis of blood, which idea I partially carried out, and shall, in a supplementary portion of this essay, describe, together with some additional later work in the same direction, not at this moment completed. Meantime, it is necessary to refer to the view here noticed, since it enters into part of the argument which follows, on the influence of purulent material on the peroxide, and of the peroxide on it, to which subject I now return.

The Peroxide and Purulent Matter.

The influence of pus on the peroxide is modified by temperature. The disintegrating process is quickened greatly by heat. At fever heat of 105° F., the escape of the gas, even when the solution is one of five volumes only, is so intensified as to cause a brisk effervescence. While the escape is in progress, the purulent fluid lies at the upper surface of the solution, as a rather thick and yeast-like covering. After a time, the covering contracts with or from escape of contained gas, and the mass assumes a cheesy or caseous appearance, resembling the caseous substance which is found not infrequently in a chronic abscess. Later on the mass sinks to the bottom of the containing vessel, and if left there, with a little fresh peroxide added to it, passes almost altogether into what we should call, in disease, a sanious fluid. In short, the changes, throughout, are singularly like what we observe in a deep-seated abscess of long standing, and indicate that the mode in which pus is changed, in chronic abscess, is a slow oxidation, the oxygen being derived from the blood. The lesson is pregnant of suggestion. Whenever pus is present in large quantities in the body, the deoxidation of blood that must be going on fully accounts for the depression that is so often fatal. In confluent smallpox, when the wide cutaneous surface is covered with pustular eruption, when the skin is one sheet of purulent matter, it is no wonder that the blood is deoxidized, and that there should be those signs of asphyxia which the old physicians called black or suffocative variola.

I take it as all but certain that what is designated hectic fever is brought about in a similar manner. In conditions during which hectic is a periodical phenomenon, purulent material is formed in the tissues, and, accumulating to a given point of saturation for becoming active, begins at last to liberate too freely the oxygen from the blood. Then occurs the febrile stage, a stage which continues until the purulent material is reduced to a neutral condition by oxidation. After that the febrile heat ceases; a copious supply of water formed, as a necessity, during the period of excessive action, is liberated by the skin, and the final result is extreme exhaustion, which continues until, in the process of reaction, there is a new formation of purulent substance, reaccumulation and again destruction. In all febrile states leading up to purulent formations this, probably, is the natural course toward recovery or death.

After observing these active effects from purulent material, I set myself to learn what would be the action of other substances which sometimes play an important part in the phenomena of disease; and, with this object in view, I fitted up a small chamber like that used for the incubation of eggs, in which I could secure and sustain a temperature varying from 96° F. to 110°, at any degree within this range, for any requisite period of time. Into this chamber I introduced flasks charged with the peroxide solution combined with the substances to be subjected to experiment, exposed them to a fixed temperature, and, collecting the gases evolved and measuring them, determined the degree of action in each case. I followed also another line of inquiry. After charging a flask with the peroxide solution and with an organic substance that would not produce separation of oxygen, I closed the flask firmly with its contents in combination with a minute division of another substance, like black oxide of platinum, which would, by its presence, cause liberation. By this means I was able to trace the course of oxidation, under pressure, of different organic substances, as well as the resolution of those substances into new combinations.

Infected Flasks.

In the course of these last named experiments, a singular observation was made, which, even if it lead to nothing of moment immediately, even if it be but one of those mites in science which Benjamin Rush speaks of, is worth recording. I noticed that sometimes the flask in which the experiment was made would afterward evolve oxygen from the peroxide solution, although it had been emptied of its contents, washed, and rinsed over and over again with fresh water. I called these flasks infected flasks, and I showed one of them at the meeting of the Medical Society of London, before which this paper was read. I had a flask which retained this property for years, and would permit of having distilled water boiled in it without losing the property. The explanation of the phenomenon is, I think, simple enough. I suspect that the glass possesses, in these instances, a certain degree of porosity, and that the disturbing body is left in these pores in minute subdivision of an infinite fineness. But simple as such an explanation may be, it carries with it a lesson. It shows that minute disturbing causes may be obscurely laid by, and, under favoring conditions, show an activity as strange as those mysterious phenomena called vital and hereditary.

The Peroxide and Decomposing Matter.

After observing the action of the peroxide with purulent matter, I extended the inquiry. I found that some decomposing substances, such as fibrine, which ordinarily release the oxygen from the solution, release it more rapidly when they are undergoing decomposition than when they are in the fresh state. Fibrine itself, when it was fresh and washed to perfect whiteness, would slowly liberate the oxygen, but if it were put into the solution when it had commenced to decompose, the action was greatly expedited. Another fact also was elicited, namely, that with the more rapid action the disturbing substance itself—the fibrine—underwent more rapid dissolution, and at the same time lost the offensive odor due to decomposition. If the fibrine were put into the solution in the fresh state, it would remain for weeks unchanged in character at a moderate atmospheric temperature; but if it were put in during process of decomposition it was broken up, and became sanious, like pus under the same influence.

I wondered if bodies which do not set the oxygen free when they are immersed in the solution in their fresh state would do so if they were immersed in it in the state of decomposition. Albumen was tested. Albumen, obtained from the serum of blood, which, in its fresh state, had no effect, was allowed to decompose in water and was again tested. This time there could be no doubt that liberation, with quick dissolution and removal of putrefactive odor, took place, but why did not appear obvious. It seemed to me as if something had been unloosed by the decomposition which created the effect; and seeing the action of carbonic acid in the same direction, I suspected that it was the disturbing cause, but I do not find in my notes any proof from experiment. I suppose, therefore, it was a suggestion left for elucidation.

Some other experiments bearing on albumen are of moment. I discovered that if fresh albumen were mixed with the neutral peroxide solution, and then with organic substances that would liberate the oxygen, pus for example, the albumen would quickly resolve and pass into solution. These substances, in short, act like ferments in the presence of the oxygen; they set the active oxygen at liberty, and then it begins to attack and break up the compounds with which it comes in contact. For the same reason that it decomposes potassium iodide in the ozone test paper, it breaks up the products of decomposition, in which respect it acts like ozone, and I shall show how these observations led to the employment of the solution, by external application and in form of spray, in the treatment of fetid surfaces, and in the purification of the air of sick rooms. These results of breaking up of tissue carried me further on in similar lines. I inquired as to the action of the peroxide on decomposing saccharine matter. Solutions were made of grape sugar, and the products evolved by fermentation by means of yeast were taken as a standard. Next, the changes in fermentation in the presence of peroxide were noted; and in continuation of the same course of experiment, the yeast was substituted by such bodies as black oxide of platinum, oxide of manganese, permanganate of potassa, muscular flesh, portions of the structure of the lung, cellular tissue, and fibrine in the moist state. If the peroxide were left to act on the grape sugar alone, at 100° F., carbonic acid was evolved and the sugar was resolved into its secondary compounds; but the process was slow. Something was required to give the start to the action in order to make it lively, and then it went on without delay. It was astonishing to see what a very little would effect the start, and how long the activity would continue, when the start had commenced, without further provocation from what we may call the fermenting or provoking body.

A strange practical problem lies here, connected with what may be called starts in new directions, during chemical action, and of progressions in the new directions in continuance of the initiative. To explain best what I mean on this curious point, I will put an elementary fact into the foreground in illustration. If the solution of peroxide of hydrogen be simply exposed to heat in a clean glass vessel, it can be heated up to boiling point before the additional oxygen will begin to go off. At boiling point the oxygen will be liberated, and, once started, it will go on being liberated until all of it has escaped, although it be rapidly cooled down to the common atmospheric temperature. The start has given the direction, and the effect continues to the end, until every part of additional oxygen has made its escape, and nothing but water or monoxide of hydrogen remains. In another way the same thing takes place under the catalytic action of substances added to the solution. A point of black oxide of platinum will start the action by its presence, and the action will continue. Again, the presence of some decomposable organic substance will start the action, and will keep it up so long as it is itself decomposable. Lastly, and this, physiologically and pathologically, is most important of all, the process of disintegration being set up in matter of an organic kind, which in its natural condition would be neutral, secondary products will sustain the action so long as any oxygen and any product remain to react on each other.

I cannot press this conclusion home too far, in its bearing on the study of disease. If the blood in the living body holds its oxygen, as I have previously suggested, in the same manner as the water of the peroxide solution holds its oxygen, then we can see why from one small point of infection general infection may follow in the body. The locally infected spot becomes the seat of a change by which the formation of a new and disturbing product is formed; that disturbing product carried into the blood increases naturally, sets free more oxygen, enlarges the process of action, and at last brings the whole of the vital tissues into the catastrophe of fever heat, forced oxidation, with all the consequences of dissolution, and with the ordinary aliments of the body feeding the unnatural fire, until, from failure of oxygen, or from failure of fuel, the overaction ceases.

Organic bodies of a fixed nature, like albumen and sugar, are thus rendered decomposable in the presence of oxygen in continuous line, so soon as their decomposition has once been commenced. It is, I believe, just the same event as that which takes place when we set fire to a piece of wood. The fire may be started from the minutest point, but feed that point with oxygen, and the fire goes on until all the fuel is decomposed. The organic substances, when once the change is started in them, burn away like wood, not truly with the fury of heat exalted into flame, for the presence of undecomposed water prevents that, but with radiation of heat—fever—as a part of the process. Fever, in brief, is active combustion in water.

These facts bring near to us, and into one common view, the processes both of catalysis and of fermentation. When, on mixing peroxide solution with decomposable matter, we start oxidation of that matter, from the addition of a point of black oxide of platinum, we set up movement by what we must designate catalysis. We cannot fairly call this fermentation, because the exciting substance is inorganic. When, however, we start the change from a point of purulent matter, we must designate the process one of fermentation. We cannot call this catalysis, because the exciting substance is organic, and is itself capable of destruction in the course of the disturbance it has set up. Yet the two processes are, practically, the same.

Another series of experiments were made with dried undecomposed pulverized fibrine and dried undecomposed pulverized albumen, both obtained from the blood of an ox, and both reduced to an impalpable powder. The fibrine added to the peroxide liberated the oxygen, the albumen exerted no action whatever. By the fibrine I could excite direct oxidation of any organic substance of a decomposable kind with which the solution was commingled; with the albumen I could excite no action whatever, until the process was started by some organic or inorganic disturbing body. Here we are brought into the actual presence of catalysis and of zymosis, in organic bodies, as the same processes; and, perhaps, one day there may be found here the ground of reconciliation between the representatives of the popular school of microbians and the broader, but for the moment unpopular, school of physicians.

THERAPEUTICAL OBSERVATIONS.

From these debatable subjects I turn now, for a time, to others more directly practical, confining myself, in the present number, to the earliest observations on the peroxide of hydrogen as a therapeutical agent.

Ozonic Ether.

In turning to therapeutical action, let me notice in the first place a few new facts bearing on modes of administration of the peroxide. Some time about 1863, I made an observation on the behavior of the peroxide with ether. In agitating a thirty-volume solution of it with anhydrous ether I found that the ether became ozonized, and that it was in this way possible to make a new and useful medicinal preparation. To the preparation so formed I gave the name of ozonic ether, and from the time when it was first announced until the present time it has been utilized. The late Dr. Day, of Geelong, in Australia, sent to me early for its mode of preparation, and having learned to use the ozonic ether in his own practice, devoted to it much study up to the end of his valuable life. He warmly supported my application of the fluid in the treatment of whooping cough, as well as its use for inunction after scarlet fever. It was he who first employed the compound with guaiacum as a blood test.

Peroxide Spray.

The admixture of the peroxide with a volatile compound, like ether, led me to another modification, namely, the administration, by inhalation, of the oxygen evolved either as oxygen, ethereal oxygen, or ozone, for I soon learned that it could be administered in all these states. This was a distinct advantage, as it enabled me to move from the mode of administration by the mouth to a larger and, in cases of lung disease, a more direct method. Taking further advantage of the ozonic properties of the peroxide solution, I introduced it in 1865 at the meeting of the British Medical Association at Chester for the deodorization and disinfection of rooms in which patients suffering from infectious diseases are under treatment, and also for application as spray to fetid, ulcerated, or decomposed surfaces, as in diphtheria, ulceration of the throat, and gangrene.

Employment in Treatment.

In the paper of 1862 I reported many cases of disease, in which I had applied the peroxide as a remedy; and in respect to all the forms of diseases then specified I may say that in the long experience which has

*Continued from a research commenced in the year 1856.—*From the Asclepiad.*

succeeded I have nothing of moment to retract, little to modify, much to emphasize and support.

In Diabetes.—I have many times prescribed the peroxide solution in diabetes since 1862. In four cases of the disease, in members of our own profession, the patients were all satisfied of benefit from it, one of them taking it for a period of eleven years. The results have always been that it reduced the quantity of sugar, but did not reduce the quantity of water eliminated, unless it were combined with codeine, with the use of which Dr. Pavy has made us so familiar. Codeine *three* grains, alcohol (sp. gr. 0·830) *two* fluid drachms, solution of peroxide of hydrogen (10 volume strength) *two* fluid ounces, distilled water to make *twelve* ounces. This forms a mixture of which half a fluid ounce may be taken three times a day in a wineglassful of water. It is the most useful medicine I have ever prescribed in diabetes.

In Phthisis Pulmonalis.—In the treatment of *phthisis pulmonalis* the solution has been constantly in use, and from it I have found the greatest service. In some cases in which the solution has been borne in large doses—3 iv of ten-volume strength well diluted with water—during the early stages, it has led to such good results, I might almost have been pardoned if in younger and more enthusiastic days I had declared in it the discovery of a specific. Happily, a natural fear of the *experientia fallax* held me back from such a course; but the fact ought not to prevent me from stating that in the first stages of phthisis it is of all remedies I know of the most valuable; and that in the later stages, when dyspnœa is the distressing symptom, it is, especially in the form of ozonic ether, the remedy that gives most relief. It soothes, and, as if it supplied oxygen to the blood, seems to act vicariously for the purpose of respiration.

In Pertussis.—I repeat all I have previously said about the value of the peroxide in the treatment of whooping cough. I am sure there is nothing so near to a specific for this affection. The only difference I have instituted in the employment of it in this disease consists in prescribing it in the form of ozonic ether. I prescribe it now for children in this form, in doses of from ten to sixty minims, diluted with half a fluid drachm of spiritus tenuoris and four drachms of water, to be taken four times a day, with a little more water if that be preferred. But I also administer the ozonic ether in this disease by inhalation from the Siegel spray inhaler. In one instance, where the paroxysms were as severe as I have ever seen them, they were arrested at once by this inhalation, and were held in such control by continued inhalations of it that what may be called a "cure" was the immediate result.

In Asthma and Angina Pectoris.—It will be remembered that the power of the oxygen to control muscular action has been referred to, and, once more, I repeat with still more earnest insistence this fact. In practice I have availed myself of the peroxide as ozonic ether, not only in whooping cough, but also in asthma and in angina pectoris. Here the ethereal solution can be used in its simple form, or combined with amyl nitrite, or other volatile body of the anti-spasmodic class that will admix and diffuse with ether. In these affections I prefer to administer it by inhalation, but it can also be prescribed by the mouth in diluted spirit solution.

In Syphilis.—I repeat the value of the peroxide in secondary syphilis, and in all the chronic stages and conditions of syphilis in which mercury or potassium iodide would, usually, be resorted to. It seems to me, in these cases, to have an intermediate action between mercury and potassium iodide. It is also useful in indolent syphilitic eruptions, and it has the great advantage over both mercury and the iodide that it leaves no after effects of an injurious character. Salivation from large and frequently repeated doses is soon recovered from after it is withdrawn, as if the ptyalism had been induced by a volatile substance. It aids the action of mercury, rendering much smaller doses of that remedy effective. The property exemplified in this action is that of elimination by excitement of glandular function; an excitement probably always sustained by the oxygen of the tissues in normal states of health, and only accelerated by the active oxygen. I have of late years become so confident of the value of the peroxide in the treatment of syphilis under the conditions in which mercury or iodide come ordinarily into use that I have employed it as a matter of course. I use it in the primary as well as the secondary form of the disease, and for those cachectic lesions in the syphilitic constitution to which the term "tertiary" is applied there is, I think, no remedy equal to it. In obstinate cases of ulcer and cutaneous eruption it goes admirably with the mercurial bath, and may be prescribed in doses of from two to four drachms three times a day with full doses of fresh cinchona infusion. The solution also has its local use. It makes an excellent injection into the nasal cavity when there is syphilitic ulceration of the cartilage and spongy bones, syphilitic ozœna.

Local Use for Sphacelus and Purulent Exudation.—In the paper of 1862 I recommended the use of the peroxide for external application in cases of surface decomposition and ulceration. This followed, naturally enough, from what I had observed in regard to the action of the peroxide with decomposing and purulent matter. I have to emphasize this use. I will name one case alone in illustration. I was called to see a gentleman advanced in life who was suffering from moist senile gangrene of the foot. The odor from the dead extremity was most offensive, and the separation slow, although there was a fair line of separation. I had the foot wrapped in cotton wool, holding the peroxide solution slightly acidulated with dilute hydrochloric acid. The offensive odor was at once removed, and the process of separation went on rapidly. The foot soon fell off, leaving an excellent healing surface. The patient lived many years afterward in fair health, and died at last of mere old age. In examples of bed sore the same useful service is rendered.

In Gonorrhœa.—The local action of the peroxide in acute purulent affections is quite remarkable. In such a specific purulent affection as gonorrhœa I have seen an injection of it transform the purulent into an aqueous discharge in forty-eight hours. In this disease the solution for injection must be of neutral reaction and weak: in the beginning two fluid drachms of a solution of three-volume strength is amply sufficient, and that may be reduced in strength by further dilution with water, if it causes pain, or if effervescence from the escape of oxygen is too active.

In first employing the solution for injection in gonorrhœa, I prescribed a solution of five volumes, which was rapidly effective, but rather painful. I then reduced the strength to three volumes, and found as good an effect without pain, and with very little loss of time. In gonorrhœa it is also good to have the solution applied to the glans as a wash or lotion for the destruction of purulent matter that may gather on the surface and under the prepuce.

USE IN PLEURO-PNEUMONIA.

In observing the special action of the peroxide of hydrogen in the above and other diseases affecting man, it has occurred to me that it might exert the same useful specific effect on animals (cattle) suffering from pleuro-pneumonia. In this disease the solution could be injected by needle injection into the pleural cavity of the infected animal; but a second puncture would, perhaps, have to be made to give exit to the gas liberated, should too much gaseous pressure be inflicted on the lung. From absorption of oxygen by the lung there could be no danger beyond emphysema, and that would not occur if care were taken to avoid pressure. A ten-volume neutral solution would be of sufficient strength.

(To be continued.)

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